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MC SYLLABUS 47.1

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**NUMAL**  
**NUMERICAL PROCEDURES IN ALGOL 60**

GENERAL INFORMATION AND INDICES

P.W. HEMKER (ed.)

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MATHEMATISCH CENTRUM      AMSTERDAM 1981

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THE LIBRARY  
OF ALGOL 60 PROCEDURES IN NUMERICAL MATHEMATICS  
PROGRAM TEXTS AND DOCUMENTATION

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MATHEMATICAL CENTRE , AMSTERDAM  
4-TH REVISION, 1980

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NUMAL  
OF ALGOL 60 PROCEDURES IN NUMERICAL MATHEMATICS

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GENERAL INFORMATION AND INDICES

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## INTRODUCTION.

AT REQUEST OF THE ACADEMIC COMPUTING CENTRE OF AMSTERDAM (SARA) THE MATHEMATICAL CENTRE STARTED IN 1973 THE ADAPTATION OF ITS COLLECTION OF NUMERICAL PROCEDURES FOR USE WITH THE CD CYBER 70 SYSTEM. THE RESULTING NUMERICAL LIBRARY IS CALLED "NUMAL" ( "NUM" ERICAL PROCEDURES IN "AL" GOL 60 ).

THE DOCUMENTATION APPEARED IN 1974 IN A LOOSE LEAF MANUAL. IT WAS REVISED AND UPDATED IN 1975, 1977 AND 1979. IN THIS PERIOD THE LIBRARY GREW TO A COLLECTION OF ABOUT 430 ROUTINES IN ALL DIFFERENT FIELDS OF NUMERICAL MATHEMATICS. ALTHOUGH NO ATTEMPTS HAVE BEEN MADE TO CREATE A COLLECTION THAT GIVES A COMPLETE OVERVIEW OF ALL NUMERICAL PROCEDURES AVAILABLE, MOST AREAS OF NUMERICAL MATHEMATICS ARE COVERED AND MOST PROGRAMS FOR WHICH A NEED WAS FELT HAVE BEEN IMPLEMENTED.

THE AIM OF NUMAL WAS TO PROVIDE ALGOL 60 PROGRAMMERS WITH A HIGH LEVEL NUMERICAL LIBRARY WHICH CONTAINS A SET OF VALIDATED NUMERICAL PROCEDURES TOGETHER WITH SUPPORTING DOCUMENTATION.

THE LIBRARY HAS BEEN CONSTRUCTED IN A MODULAR WAY: MOST ROUTINES REFER TO AND RELY ON OTHER ROUTINES THAT PERFORM A WELL-DEFINED SUB-TASK. THE MORE EXPERIENCED USER CAN AVAIL HIMSELF OF THESE MORE ELEMENTARY ROUTINES IN THE SAME WAY AS THE AUTHORS OF THE LIBRARY DO. THE NOVICE, IT IS BETTER TO USE THE MORE COMPREHENSIVE PROCEDURES WHICH PERFORM COMPLETE MATHEMATICAL COMPUTATIONS.

IN 1976 AND 1977 THE NUMERICAL MATHEMATICS DEPARTMENT ORGANIZED A SEMINAR ON NUMERICAL SOFTWARE. IN THIS SEMINAR THE USE OF SOME ALGOL PROCEDURES IN THE NUMAL LIBRARY WAS EXPLAINED IN DETAIL AND THEIR ALGORITHMIC BACKGROUND WAS CLARIFIED. ALSO, THE NUMERICAL LIBRARIES IMSL (FORTRAN), NAG (ALGOL 60 AND FORTRAN) AND NUMAL (ALGOL 60) WERE COMPARED. THE PROCEEDINGS OF THIS SEMINAR APPEARED (IN DUTCH) IN THE MC-SYLLABUS SERIES OF THE MATHEMATICAL CENTRE AS:

COLLOQUIUM NUMERIEKE PROGRAMMATUUR, DEEL 1  
J.C.P.BUS ED., MCS 29.1,  
MATHEMATISCH CENTRUM, AMSTERDAM, 1976,

AND

COLLOQUIUM NUMERIEKE PROGRAMMATUUR, DEEL 2  
H.J.J. TE RIELE ED., MCS 29.2,  
MATHEMATISCH CENTRUM, AMSTERDAM, 1977.

## THE LANGUAGE ALGOL 60 AND THE MODULAR STRUCTURE

TWO IMPORTANT CHARACTERISTICS OF NUMAL ARE : ITS MODULAR STRUCTURE AND THE CONSISTENT USE OF STANDARD ALGOL 60 (IN THE SENSE OF THE REVISED REPORT ON ALGOL 60, REF.)

INPUT AND OUTPUT ROUTINES, NOT BEING DEFINED IN STANDARD ALGOL 60, HAVE NOT BEEN USED IN THE LIBRARY SOURCE TEXTS. THEY ONLY APPEAR IN THE DOCUMENTATION WHERE EXAMPLES OF USE OF THE LIBRARY ROUTINES ARE GIVEN.

SINCE DOUBLE PRECISION IS ALSO NOT DEFINED IN ALGOL 60, A SMALL NUMBER OF DOUBLE PRECISION ARITHMETIC ROUTINES COULD NOT BE CODED IN ALGOL 60 AND, HENCE, A FEW (8) DOUBLE PRECISION MODULES WERE CODED IN ASSEMBLY LANGUAGE.

EXCEPT FOR THIS SMALL NUMBER OF DOUBLE PRECISION ARITHMETIC ROUTINES ALL THE SOURCE TEXTS ARE WRITTEN IN ALGOL 60 AND, HENCE, THEY ARE IN PRINCIPLE INDEPENDENT OF THE COMPUTER/COMPILER USED (REF.).

IN ITS PRACTICAL IMPLEMENTATION ON THE CDC-CYBER SYSTEM MOST ELEMENTARY ROUTINES IN THE MODULAR STRUCTURE OF THE LIBRARY ( I.E. THE MATRIX AND VECTOR OPERATIONS ) WERE RE-CODED BY HAND IN ASSEMBLY LANGUAGE. THIS HAS ACCELERATED THE OPERATION OF MOST LINEAR ALGEBRA ROUTINES BY A FACTOR 2.5. THUS, ONE OF THE MAJOR DISADVANTAGES OF THE USE OF ALGOL 60, THE RELATIVELY LONG EXECUTION TIMES ( WHICH FIRST WERE APPROXIMATELY 4 TIMES LONGER THAN FOR AN EQUIVALENT FORTRAN PROGRAM ) WAS CIRCUMVENTED TO A LARGE EXTENT. THIS REFINEMENT WAS POSSIBLE BECAUSE OF THE CONSISTENT APPLICATION OF THE MODULARITY PRINCIPLE.

## REFS. P.NAUR (ED.)

REVISED REPORT ON THE ALGORITHMIC LANGUAGE ALGOL 60  
A/S REGNECENTRALEN, COPENHAGEN, 1964.

P.W.HEMKER

CRITERIA FOR TRANSPORTABLE ALGOL LIBRARIES.

IN: PORTABILITY OF NUMERICAL SOFTWARE (W.COWELL ED.)

LECTURE NOTES IN COMP.SC. 57, SPRINGER VERLAG, 1977.

## ORGANIZATION OF THE LIBRARY.

EACH ROUTINE IN THE LIBRARY IS IDENTIFIED BY A NAME AND A CODE NUMBER. THE CODE NUMBER CAN BE USED IN AN ALGOL 60 PROGRAM WHEN REFERENCE IS MADE TO A PRE-COMPILED PROCEDURE IN THE OBJECT CODE LIBRARY. ALL PROCEDURES IN NUMAL ARE CLASSIFIED ACCORDING TO SUBJECT. THE SUBJECTS ARE IDENTIFIED BY A SECTION NUMBER. THE MANUAL IS ORDERED BY THESE SECTION NUMBERS.

IN ORDER TO FIND A PARTICULAR PROCEDURE, THERE IS A SYSTEMATIC INDEX IN WHICH ALL PROCEDURES (THEIR NAMES AND THEIR CODE NUMBERS) ARE RECORDED AND CLASSIFIED BY THEIR SECTION NUMBER (I.E. BY SUBJECT).

FOR CROSS REFERENCING THERE IS AN INDEX BY CODE NUMBER, WHICH HAS REFERENCES TO PROCEDURE NAME AND SECTION NUMBER, AND THERE IS ALSO A KWIC INDEX IN WHICH KEYWORDS AND PROCEDURE NAMES HAVE BEEN ORDERED ALPHABETICALLY.

## THE STATUS OF NUMAL

IN 1979 THE INTEREST AT THE MATHEMATICAL CENTRE IN THE CREATION OF GENERAL NUMERICAL SOFTWARE IN ALGOL 60 DECREASED AND THE DRAFTING-COMMITTEE DECIDED TO CONCLUDE THE NUMAL-PROJECT WITH THE PUBLICATION OF A FINAL REVISION OF THE LIBRARY IN BOOK FORM. IN ITS PRESENT FORM THE LIBRARY NUMAL CAN BE SEEN AS A DESCRIPTION OF THE STATE-OF-THE-ART OF NUMERICAL ALGOL 60 PROGRAMMING AT THE MATHEMATICAL CENTRE AT THE END OF THE 1970-S.

WE THINK THAT IT CONTAINS A VALUABLE COLLECTION OF ROUTINES IN A LANGUAGE THAT STILL CAN DESCRIBE NUMERICAL PROCEDURES BETTER THAN MANY OTHER PROGRAMMING LANGUAGES CURRENTLY IN USE.

## IMPERFECTIONS AND RESPONSIBILITY.

ALTHOUGH THE NUMERICAL MATHEMATICS DEPARTMENT OF THE MATHEMATICAL CENTRE ASSUMES THE RESPONSIBILITY FOR IMPERFECTIONS BOTH IN PROGRAMS AND IN DOCUMENTATION, NEITHER THE MATHEMATICAL CENTRE NOR THE AUTHORS/CONTRIBUTORS ACCEPT RESPONSIBILITY FOR THE CONSEQUENCES OF SUCH IMPERFECTIONS.

ALTHOUGH MUCH EFFORT HAS BEEN SPENT TO KEEP THE NUMBER OF ERRORS TO A MINIMUM, IT IS POSSIBLE THAT SOME MINOR ERRORS STILL REMAIN. THEREFORE THE NUMERICAL MATHEMATICS DEPARTMENT WILL KEEP A LIST OF ALL ERRORS IN THE DOCUMENTATION AND/OR THE PROGRAMS THAT BECOME KNOWN AFTER PUBLICATION AND THIS LIST WILL BE MADE AVAILABLE UPON REQUEST.

## NUMAL IN FORTRAN.

A TRANSLATION OF NUMAL INTO A FORTRAN VERSION SUITABLE FOR USE ON A MINI-COMPUTOR IS CARRIED OUT UNDER THE SUPERVISION OF P.WYNN BY H.T.LAU IN THE SCHOOL OF COMPUTER SCIENCE, MC-GILL UNIVERSITY, MONTREAL, CANADA.

FURTHER RESEARCH ON THE FORTRAN VERSION IS ALSO BEING CARRIED OUT AT IIMAS (INSTITUTO DE INVESTIGACIONES EN MATEMATICAS APLICADAS Y EN SISTEMAS), UNIVERSIDAD NACIONAL AUTONOMA DE MEXICO.

## ORIGIN OF THE PROGRAMS.

THE MAJOR PART OF THE LIBRARY CONSISTS OF PROCEDURES THAT HAVE BEEN DEVELOPED AT THE MATHEMATICAL CENTRE. HOWEVER, SOME PROCEDURES ARE ADAPTED VERSIONS OF PROCEDURES PUBLISHED IN THE OPEN LITERATURE. IN PARTICULAR A NUMBER OF PROGRAMS ARE DERIVED FROM PROCEDURES PUBLISHED BY A. BJÖRCK, R. BULIRSCH, J.R. BUNCH, G.H. GOLUB, L. KAUFMAN, B. LINDBERG, B.N. PARLETT, C. REINSCH AND J. STOER.



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## ACKNOWLEDGEMENTS.

THE LIBRARY NUMAL HAS BEEN DEVELOPED BY THE JOINT EFFORTS OF THE MEMBERS OF THE LIBRARY GROUP OF THE NUMERICAL MATHEMATICS DEPARTMENT OF THE MATHEMATICAL CENTRE. IN PARTICULAR, HOWEVER, WE WANT TO ACKNOWLEDGE THE MEMBERS F. GROEN, K. VAN 'T HOFF, R. PISCAER, B.P. SOMMEIJER, G.J.F. VINKESTEYN, WHO TOOK CARE OF FILE MANIPULATION, EDITING OF THE DOCUMENTATION FILES AND ADAPTION AND RUNNING OF THE KWIC INDEX PROGRAM.

FURTHER WE WANT TO ACKNOWLEDGE THE MEMBERS OF THE DRAFTING COMMITTEE: C.DEN HEYER, P.J.VAN DER HOUWEN, J.KOK, N.M.TEMME AND D.T.WINTER, AND THE EXTERNAL ADVISORS: TH.J.DEKKER, W.HOFFMANN (UNIVERSITY OF AMSTERDAM) AND C.G. VAN DER LAAN (UNIVERSITY OF GRONINGEN).

P.W. HEMKER  
GENERAL EDITOR



CLASSIFIED ACCORDING TO SUBJECT, THIS INDEX CONTAINS THE NAMES OF THE PROCEDURES AND THE CORRESPONDING CODE NUMBERS. THE DOCUMENTATION OF THE PROCEDURES IS PRESENTED IN VOLUMES 1 THROUGH 7 AND IS ARRANGED ACCORDING TO SECTION NUMBERS. HENCE REFERENCE IS IMMEDIATE.

IN ADDITION TO THE CODE NUMBER AND THE NAME OF EACH PROCEDURE THE MONTH OF FIRST APPEARANCE OF THE FINAL DOCUMENTATION IS LISTED.

DIRECTIONS TO OBTAIN A PIECE OF DOCUMENTATION  
IN MACHINE READABLE FORM  
(ONLY FOR USE WITH THE CDC CYBER 70 SYSTEM).

IN ORDER TO OBTAIN A PIECE OF DOCUMENTATION IN MACHINE READABLE FORM ONE SHOULD AVAIL OF THE NUMAL DOCUMENTATION FILE. THIS FILE MIGHT BE AVAILABLE AT YOUR COMPUTER CENTER EITHER ON A MAGNETIC TAPE OR AS A PERMANENT FILE.

THE DOCUMENTATION FILE CONSISTS OF AN EVEN NUMBER OF RECORDS (LEVEL 0) EACH SECTION OF THE NUMAL DOCUMENTATION CAN BE FOUND IN TWO SUCCESSIVE RECORDS ON THIS FILE. THE FIRST RECORD CONSISTS OF THE DESCRIPTION OF THE PROCEDURE(S) IN THAT SECTION, THE SECOND RECORD CONTAINS THE SOURCE TEXT(S).

FOR EACH SECTION OF THE NUMAL DOCUMENTATION THE RECORD NUMBER OF THE FIRST OF THE TWO RECORDS CAN BE FOUND IN THE LAST COLUMN OF THE SYSTEMATICAL INDEX.

EXAMPLE :

AT THE SARA COMPUTER CENTER (AMSTERDAM), THE DOCUMENTATION FILE IS AVAILABLE AS THE SECOND FILE ON TAPE VSN=S83281.

TO OBTAIN THE DESCRIPTION AND THE SOURCE TEXT OF THE PROCEDURE "MULTISTEP" ( SECTION 5.2.1.1.1.1 , RECORD NUMBER 151 ) FROM THE DOCUMENTATION FILE, THE FOLLOWING CONTROL CARDS CAN BE USED

LABEL,TAPE,R,L=NUMAL,ID=MC,D=PE,VSN=S83281.	
SKIPF,TAPE,1,17.	SKIP THE FIRST FILE ON TAPE
SKIPF,TAPE,150.	SKIP 150 RECORDS
COPYBR,TAPE,OUTPUT,2.	COPY TWO RECORDS

FOR USE WITH THE CD CYBER SYSTEM, THE OBJECT CODE OF THE PROCEDURES IS AVAILABLE AND IS CONTAINED IN THE LIBRARY FILE "NUMAL3". THIS LIBRARY FILE CAN BE USED WHEN PROGRAMS COMPILED UNDER ALGOL3 ARE LOADED.

FOR USE OF A LIBRARY FILE SEE E.G. CDC SCOPE REF. MANUAL, CHAPTER 6, OR THE CDC INTERCOM REF. MANUAL, CHAPTER 3, XEQ COMMAND.



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	INIMAT	* 31011	APR/74	1
	INIMATD	* 31012	APR/74	1
	INISYMD	31013	APR/74	1
	INISYNROW	31014	APR/74	1
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	DUPROWVEC	* 31032	APR/74	3
	DUPVECCOL	* 31033	APR/74	3
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	ROWCST	* 31132	APR/74	5
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	TANVEC	* 34012	DEC/75	7
	MATMAT	* 34013	DEC/75	7
	TANMAT	* 34014	DEC/75	7
	MATTAN	* 34015	DEC/75	7
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	ELMCOLVEC	* 34022	APR/74	9
	ELMVECROW	* 34026	APR/74	9
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LSQDEC	34130	730901	750701	LSQORTDEC(3.1.1.2.1.1)
ERF	35020	740501	750701	ERRORFUNCTION(6.7)
RK1N	33011	740501	750701	RKE(5.2.1.1.1.1)
LINIGER1	33130	740915	750701	LINIGER1VS(5.2.1.1.1.2)
ABSMAXVEC	31060	750101	760101	INFNRWVEC(1.1.8)
MAXMAT	34230	750101	760101	ABSMAXMAT(1.1.8)
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YAPLUSN	35076	750101	750701	BESS YAPLUSN (6.10.1)
BESSELP0	35077	750101	750701	BESS PQA01 (6.10.1)
KA	35071	750101	750701	BESS KA01 (6.10.2)
KAPLUSN	35072	750101	750701	BESS KAPLUSN (6.10.2)
NONEXPKA	35073	750101	750701	NONEXP BESS KA01(6.10.2)
NONEXPKAPLUSN	35074	750101	750701	NONEXP BESS KAPLUSN (6.10.2)
SYNDEC2	34700	790701	791231	DECSYM2 (3.1.1.1.1.3.1)
SYNDEC1	34701	790701	791231	DECSYM2 (3.1.1.1.1.3.1)
SYNDETERM2	34702	790701	791231	DETERMSYM2 (3.1.1.1.1.3.2)
SYNDETERM1	34703	790701	791231	DETERMSYM2 (3.1.1.1.1.3.2)
SYMSOL2	34704	790701	791231	SOLSYM2 (3.1.1.1.1.3.3)
SYMSOL1	34705	790701	791231	SOLSYM2 (3.1.1.1.1.3.3)
SYNDECSOL2	34706	790701	791231	DECSOLSYM2 (3.1.1.1.1.3.3)
SYNDECSOL1	34707	790701	791231	DECSOLSYM2 (3.1.1.1.1.3.3)
SYMINV2	34708	790701	791231	
SYMINV1	34709	790701	791231	
SYNDECINV2	34710	790701	791231	
SYNDECINV1	34711	790701	791231	
POLZEROS	34500	790701	791231	ZERPOL (3.6.1)

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## OBSOLETE PROCEDURES

PROCEDURE	CODE	WITHDRAWAL	EXPIRATION	REPLACED BY
RNKSVM20	34100	730901	740401	
SOLSYM20	34101	730901	731201	
RNKSOLSYM20	34102	730901	731201	
INVSVM20	34103	730901	740401	
RNKINVSVM20	34104	730901	740401	
SOLSYMOM20	34105	730901	740401	
RNKSVM10	34110	730901	740401	
SOLSYM10	34111	730901	740401	
RNKSOLSYM10	34112	730901	740401	
INVSVM10	34113	730901	740401	
RNKINVSVM10	34114	730901	740401	
DETSOL	34052	730901	740401	DECSOL(3.1.1.1.1.3), DETERM.
DETINV	34054	730901	731201	DECINV(3.1.1.1.1.4), DETERM.
RNKELM	34060	730901	740401	GSSLM(3.1.1.1.1.1)
RNKSOLELM	34062	730901	740401	GSSOL(3.1.1.1.1.3)
SOLHOM	34063	730901	740401	SINGULAR VALUE PROCEDURES (3.5)
INVELM	34064	730901	740401	GSSINV(3.1.1.1.1.4)
DETBND	34070	730901	740401	DECBND(3.1.2.1.1.1.1), DETERMBND(3.1.2.1.1.1.2)
DETSOLBND	34072	730901	740401	DECSOLBND(3.1.2.1.1.1.3), DETERMBND.
DETSYM2	34080	730901	740401	CHLDEC2(3.1.1.1.1.2.1), CHLDETERM2(3.1.1.1.1.2.2)
SOLSYM2	34081	730901	740401	CHLSOL2(3.1.1.1.1.2.3)
DETSOLSYM2	34082	730901	740401	CHLDECSOL2(3.1.1.1.1.2.3), CHLDETERM2.
INVSYM2	34083	730901	740401	CHLINV2(3.1.1.1.1.2.4)
DETINVSYM2	34084	730901	740401	CHLDECINV2(3.1.1.1.1.2.4), CHLDETERM2.
DETSYM1	34090	730901	740401	CHLDEC1(3.1.1.1.1.2.1), CHLDETERM1(3.1.1.1.1.2.2)
SOLSYM1	34091	730901	740401	CHLSOL1(3.1.1.1.1.2.3)
DETSOLSYM1	34092	730901	740401	CHLDECSOL1(3.1.1.1.1.2.3), CHLDETERM1.
INVSYM1	34093	730901	740401	CHLINV1(3.1.1.1.1.2.4)
DETINVSYM1	34094	730901	740401	CHLDECINV1(3.1.1.1.1.2.4), CHLDETERM1.
DETSYMBND	34120	730901	740401	CHLDECBND(3.1.2.1.1.2.1.1), CHLDETERMBND.
SOLSYMBND	34121	730901	740401	CHLSOLBND(3.1.2.1.1.2.1.3)
DETSOLSYMBND	34122	730901	740401	CHLDECSOLBND(3.1.2.1.1.2.1.3), CHLDETERMBND.
LSQDECSOL	34133	730901	740401	LSQORTDECSOL(3.1.1.2.1.2)
MODIFIED RUNGE KUTTA	33060	740501	740601	ARK(5.2.1.1.1.1)

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CODE	SECTION	PROCEDURE	MNT/YR
30001	6. 2.	MBASE	* JAN/76
30002	6. 2.	ARREB	* JAN/76
30003	6. 2.	DWARF	* JAN/76
30004	6. 2.	GIANT	* JAN/76
30005	6. 2.	INTCAP	* JAN/76
30006	6. 1.	PI	* JAN/76
30007	6. 1.	E	* JAN/76
30008	6. 2.	UNDERFLOW	* JAN/76
30009	6. 2.	OVERFLOW	* JAN/76
30010	6. 3.	RANDOM	
30011	6. 3.	SETRANDOM	
31010	1. 1. 1.	INIVEC	* APR/74
31011	1. 1. 1.	INIMAT	* APR/74
31012	1. 1. 1.	INIMATD	* APR/74
31013	1. 1. 1.	INISYMD	APR/74
31014	1. 1. 1.	INISYMRW	APR/74
31020	1. 1. 3.	MULVEC	* APR/74
31021	1. 1. 3.	MULROW	* APR/74
31022	1. 1. 3.	MULCOL	* APR/74
31030	1. 1. 2.	DUPVEC	* APR/74
31031	1. 1. 2.	DUPVECRW	* APR/74
31032	1. 1. 2.	DUPROWEC	* APR/74
31033	1. 1. 2.	DUPVECCOL	* APR/74
31034	1. 1. 2.	DUPCOLVEC	* APR/74
31035	1. 1. 2.	DUPMAT	* APR/74
31040	2. 2. 1. 1.	POL	OCT/75
31042	2. 2. 2. 2.	CHEPOL	DEC/78
31043	2. 2. 2. 2.	ALLCHEPOL	DEC/78
31044	2. 2. 2. 1.	ORTPOL	NOV/78
31045	2. 2. 2. 1.	ALLORTPOL	NOV/78
31046	2. 2. 2. 2.	CHEPOLSUM	DEC/78
31047	2. 2. 2. 1.	SUMORTPOL	NOV/78
31048	2. 2. 2. 1.	ORTPOLSYM	NOV/78
31049	2. 2. 2. 1.	ALLORTPOLSYM	NOV/78
31050	2. 4. 1.	NEWGRN	DEC/78
31051	2. 4. 1.	POLCHS	DEC/78
31052	2. 4. 1.	CHSPOL	DEC/78
31053	2. 4. 1.	POLSHCHS	DEC/78
31054	2. 4. 1.	SHTCHSPOL	DEC/78
31055	2. 4. 1.	GRNNEW	DEC/78
31058	2. 2. 2. 1.	SUMORTPOLSYM	NOV/78
31059	2. 2. 2. 2.	ODDCHEPOLSUM	DEC/78
31060	OBSOLETE PROCEDURE	ABSMAXVEC	
31061	1. 1. 8.	INFNRMVEC	* OCT/75
31062	1. 1. 8.	INFNRMRW	* OCT/75
31063	1. 1. 8.	INFNRMCOL	* OCT/75
31064	1. 1. 8.	INFNRMMAT	* OCT/75
31065	1. 1. 8.	ONENRMVEC	* OCT/75
31066	1. 1. 8.	ONENRMRW	* OCT/75
31067	1. 1. 8.	ONENRMCOL	* OCT/75
31068	1. 1. 8.	ONENRMMAT	* OCT/75

CODE	SECTION	PROCEDURE	MNT/YR
31069	1. 1. 8.	ABSMAXMAT	* OCT/75
31070	1. 1. 4. 3.	HSHVECMAT	* JAN/76
31071	1. 1. 4. 3.	HSHCOLMAT	* JAN/76
31072	1. 1. 4. 3.	HSHROWMAT	* JAN/76
31073	1. 1. 4. 3.	HSHVECTAM	* JAN/76
31074	1. 1. 4. 3.	HSHCOLTAM	* JAN/76
31075	1. 1. 4. 3.	HSHROWTAM	* JAN/76
31090	2. 2. 3. 1.	SINSER	OCT/74
31091	2. 2. 3. 1.	COSSER	OCT/74
31092	2. 2. 3. 1.	FOUSER	OCT/74
31093	2. 2. 3. 1.	FOUSER1	OCT/74
31094	2. 2. 3. 1.	FJUSER2	OCT/74
31095	2. 2. 3. 1.	COMFOUSER	OCT/74
31096	2. 2. 3. 1.	COMFOUSER1	OCT/74
31097	2. 2. 3. 1.	COMFOUSER2	OCT/74
31100	1. 5. 3.	LNGREATDECI	MAR/77
31101	1. 5. 1.	DP ADD	* MAR/77
31102	1. 5. 1.	DP SUB	* MAR/77
31103	1. 5. 1.	DP MUL	* MAR/77
31104	1. 5. 1.	DP DIV	* MAR/77
31105	1. 5. 1.	LNG ADD	* MAR/77
31106	1. 5. 1.	LNG SUB	* MAR/77
31107	1. 5. 1.	LNG MUL	* MAR/77
31108	1. 5. 1.	LNG DIV	* MAR/77
31109	1. 5. 1.	DP POW	MAR/77
31110	1. 5. 1.	LNG POW	MAR/77
31131	1. 1. 3.	COLCST	* APR/74
31132	1. 1. 3.	ROWCST	* APR/74
31200	1. 4.	LNGINTADD	OCT/74
31201	1. 4.	LNGINTSUBTRACT	OCT/74
31202	1. 4.	LNGINTMULT	OCT/74
31203	1. 4.	LNGINTDIVIDE	OCT/74
31204	1. 4.	LNGINTPOWER	OCT/74
31241	2. 2. 1. 1.	TAYPOL	OCT/75
31242	2. 2. 1. 1.	NORDERPOL	OCT/75
31243	2. 2. 1. 1.	DERPOL	OCT/75
31248	2. 4. 3.	INTCHS	OCT/74
31250	2. 4. 1.	LINTFMPOL	DEC/78
31252	4. 2. 3. 1.	GSSWTSSYM	NOV/78
31253	4. 2. 3. 1.	GSSWTS	NOV/78
31254	4. 2. 3. 1.	RECCOF	NOV/78
31362	3. 6. 2.	ALLZERORTPOL	DEC/78
31363	3. 6. 2.	LUPZERORTPOL	DEC/78
31364	3. 6. 2.	SELZERORTPOL	DEC/78
31370	3. 6. 2.	ALLJACZER	DEC/78
31371	3. 6. 1.	ALLLAGZER	DEC/78
31425	4. 2. 3. 2.	GSSJACWGHTS	NOV/76
31427	4. 2. 3. 2.	GSSLAGWGHTS	NOV/76
31500	1. 1. 4. 2.	FULMATVEC	* DEC/75
31501	1. 1. 4. 2.	FULTAMVEC	* DEC/75
31502	1. 1. 4. 2.	FULSYMMATVEC	DEC/75

CODE	SECTION	PROCEDURE	MNT/YR
31503	1. 1. 4. 2.	RESVEC	* DEC /75
31504	1. 1. 4. 2.	SYMRESVEC	DEC /75
31505	1. 5. 2.	LNGFULMATVEC	* JAN /76
31506	1. 5. 2.	LNGFULTAMVEC	* JAN /76
31507	1. 5. 2.	LNGFULSYMMATVEC	JAN /76
31508	1. 5. 2.	LNGRESVEC	* JAN /76
31509	1. 5. 2.	LNGSYMRESVEC	JAN /76
32010	4. 1.	EULER	JUL /74
32020	4. 1.	SUMPOSSERIES	JUL /74
32051	4. 2. 1.	INTEGRAL	JUL /74
32070	4. 2. 1.	QADRAT	JUL /74
32075	4. 2. 2.	TRICUB	OCT /75
33010	5. 2. 1. 1. 1. 1.	RK1	AUG /74
33011	OBsolete PROCEDURE	RK1N	
33012	5. 2. 1. 1. 2. 1.	RK2	AUG /74
33013	5. 2. 1. 1. 2. 1.	RK2N	AUG /74
33014	5. 2. 1. 1. 2. 1.	RK3	AUG /74
33015	5. 2. 1. 1. 2. 1.	RK3N	AUG /74
33016	5. 2. 1. 1. 1. 1.	RK4A	AUG /74
33017	5. 2. 1. 1. 1. 1.	RK4NA	AUG /74
33018	5. 2. 1. 1. 1. 1.	RK5NA	AUG /74
33033	5. 2. 1. 1. 1. 1.	RKE	DEC /75
33040	5. 2. 1. 1. 1. 3.	MODIFIED TAYLOR	AUG /74
33050	5. 2. 1. 1. 1. 3.	EXPONENTIALLY FITTED TAYLOR	AUG /74
33060	OBsolete PROCEDURE	MODIFIED RUNGE KUTTA	
33061	5. 2. 1. 1. 1. 1.	ARK	DEC /75
33066	5. 2. 1. 1. 1. 3.	ARKMAT	NOV /76
33070	5. 2. 1. 1. 1. 1.	EFRK	AUG /74
33080	5. 2. 1. 1. 1. 1.	MULTISTEP	AUG /74
33120	5. 2. 1. 1. 1. 2.	EFERK	AUG /74
33130	OBsolete PROCEDURE	LINIGER1	
33131	5. 2. 1. 1. 1. 2.	LINIGER2	AUG /74
33132	5. 2. 1. 1. 1. 2.	LINIGER1VS	OCT /74
33135	5. 2. 1. 1. 1. 2.	IMPEX	OCT /75
33160	5. 2. 1. 1. 1. 2.	EFSIRK	AUG /74
33170	5. 2. 1. 2. 2. 1. 2.	RICHARDSON	OCT /74
33171	5. 2. 1. 2. 2. 1. 2.	ELIMINATION	OCT /74
33180	5. 2. 1. 1. 1. 1.	DIFFSYS	AUG /74
33191	5. 2. 1. 1. 1. 2.	GMS	OCT /74
33300	5. 2. 1. 2. 1. 2. 1. 1.	FEM LAG SYM	JAN /76
33301	5. 2. 1. 2. 1. 2. 1. 1.	FEM LAG	JAN /76
33302	5. 2. 1. 2. 1. 2. 1. 2.	FEM LAG SKEW	JAN /76
33303	5. 2. 1. 2. 1. 2. 2. 1.	FEM HERM SYM	JAN /76
33308	5. 2. 1. 2. 1. 2. 1. 1.	FEM LAG SPHER	DEC /79
33314	5. 2. 1. 2. 1. 3.	NON LIN FEM LAG SKEW	DEC /79
34010	1. 1. 4. 1.	VECVEC	* DEC /75
34011	1. 1. 4. 1.	MATVEC	* DEC /75
34012	1. 1. 4. 1.	TAMVEC	* DEC /75
34013	1. 1. 4. 1.	MATMAT	* DEC /75
34014	1. 1. 4. 1.	TAMMAT	* DEC /75
34015	1. 1. 4. 1.	MATTAM	* DEC /75
34016	1. 1. 4. 1.	SEQVEC	* DEC /75

CODE	SECTION	PROCEDURE	MNT/YR
34017	1. 1. 4. 1.	SCAPRD1	* DEC/75
34018	1. 1. 4. 1.	SYMMATVEC	DEC/75
34020	1. 1. 5.	ELMVEC	* APR/74
34021	1. 1. 5.	ELMVECCOL	* APR/74
34022	1. 1. 5.	ELMCOLVEC	* APR/74
34023	1. 1. 5.	ELMCOL	* APR/74
34024	1. 1. 5.	ELMRGW	* APR/74
34025	1. 1. 5.	MAXELMRGW	* APR/74
34026	1. 1. 5.	ELMVECROW	* APR/74
34027	1. 1. 5.	ELMRWVEC	* APR/74
34028	1. 1. 5.	ELMRWCOL	* APR/74
34029	1. 1. 5.	ELMCOLROW	* APR/74
34030	1. 1. 6.	ICHVEC	* APR/74
34031	1. 1. 6.	ICHCOL	* APR/74
34032	1. 1. 6.	ICHROW	* APR/74
34033	1. 1. 6.	ICHROWCOL	* APR/74
34034	1. 1. 6.	ICHSEQVEC	* APR/74
34035	1. 1. 6.	ICHSEQ	* APR/74
34040	1. 1. 7.	ROTCOL	* APR/74
34041	1. 1. 7.	ROTROW	* APR/74
34050	OBSOLETE PROCEDURE	DET	
34051	3. 1. 1. 1. 1. 1. 3.	SOL	MAY/74
34052	OBSOLETE PROCEDURE	DETSOL	
34053	3. 1. 1. 1. 1. 1. 4.	INV	MAY/74
34054	OBSOLETE PROCEDURE	DETINV	
34060	OBSOLETE PROCEDURE	RNKELM	
34061	3. 1. 1. 1. 1. 1. 3.	SOLELM	MAY/74
34062	OBSOLETE PROCEDURE	RNKSOLELM	
34063	OBSOLETE PROCEDURE	SOLHOM	
34064	OBSOLETE PROCEDURE	INVELM	
34070	OBSOLETE PROCEDURE	DETBND	
34071	3. 1. 2. 1. 1. 1. 1. 3.	SOLBND	JUN/74
34072	OBSOLETE PROCEDURE	DETSOLBND	
34080	OBSOLETE PROCEDURE	DETSYM2	
34081	OBSOLETE PROCEDURE	SOLSYM2	
34082	OBSOLETE PROCEDURE	DETSOLSYM2	
34083	OBSOLETE PROCEDURE	INVSYM2	
34084	OBSOLETE PROCEDURE	DETINVSYM2	
34090	OBSOLETE PROCEDURE	DETSYM1	
34091	OBSOLETE PROCEDURE	SOLSYM1	
34092	OBSOLETE PROCEDURE	DETSOLSYM1	
34093	OBSOLETE PROCEDURE	INVSYM1	
34094	OBSOLETE PROCEDURE	DETINVSYM1	
34100	OBSOLETE PROCEDURE	RNKSYM20	
34101	OBSOLETE PROCEDURE	SOLSYM20	
34102	OBSOLETE PROCEDURE	RNKSOLSYM20	
34103	OBSOLETE PROCEDURE	INVSYM20	
34104	OBSOLETE PROCEDURE	RNKINVSYM20	
34105	OBSOLETE PROCEDURE	SOLSYMHOM20	
34110	OBSOLETE PROCEDURE	RNKSYM10	
34111	OBSOLETE PROCEDURE	SOLSYM10	



CODE	SECTION	PROCEDURE	MNT/YR
34112	OBSOLETE PROCEDURE	RNK SOLSYM10	
34113	OBSOLETE PROCEDURE	INVSYM10	
34114	OBSOLETE PROCEDURE	RNKINVSYM10	
34120	OBSOLETE PROCEDURE	DETSYMBND	
34121	OBSOLETE PROCEDURE	SOLSYMBND	
34122	OBSOLETE PROCEDURE	DETSOLSYMBND	
34130	OBSOLETE PROCEDURE	LSQDEC	
34131	3. 1. 1. 2. 1. 2.	LSQSOL	MAY/74
34132	3. 1. 1. 2. 1. 1.	LSQDGLINV	MAY/74
34133	OBSOLETE PROCEDURE	LSQDEC SOL	
34134	3. 1. 1. 2. 1. 1.	LSQORTDEC	MAY/74
34135	3. 1. 1. 2. 1. 2.	LSQORTDECSOL	MAY/74
34136	3. 1. 1. 2. 1. 3.	LSQINV	OCT/74
34137	3. 1. 1. 2. 1. 4.	LSQDECOMP	DEC/78
34138	3. 1. 1. 2. 1. 4.	LSQREFSOL	DEC/78
34140	3. 2. 1. 2. 1. 1.	TFMSYMTRI2	JUN/74
34141	3. 2. 1. 2. 1. 1.	BAKSYMTRI2	JUN/74
34142	3. 2. 1. 2. 1. 1.	TFMPREVEC	JUN/74
34143	3. 2. 1. 2. 1. 1.	TFMSYMTRI1	JUN/74
34144	3. 2. 1. 2. 1. 1.	BAKSYMTRI1	JUN/74
34150	5. 1. 1. 1. 1.	ZEROIN	OCT/75
34151	3. 3. 1. 1. 1.	VALSYMTRI	JUL/74
34152	3. 3. 1. 1. 1.	VECSYMTRI	JUL/74
34153	3. 3. 1. 1. 2.	EIGVALSYM2	JUL/74
34154	3. 3. 1. 1. 2.	EIGSYM2	JUL/74
34155	3. 3. 1. 1. 2.	EIGVALSYM1	JUL/74
34156	3. 3. 1. 1. 2.	EIGSYM1	JUL/74
34160	3. 3. 1. 1. 1.	QRIVALSYMTRI	JUL/74
34161	3. 3. 1. 1. 1.	QRISYMTRI	JUL/74
34162	3. 3. 1. 1. 2.	QRIVALSYM2	JUL/74
34163	3. 3. 1. 1. 2.	QRISYM	JUL/74
34164	3. 3. 1. 1. 2.	QRIVALSYM1	JUL/74
34170	3. 2. 1. 2. 1. 2.	TFMREAHES	JUN/74
34171	3. 2. 1. 2. 1. 2.	BAKREAHES1	JUN/74
34172	3. 2. 1. 2. 1. 2.	BAKPEAHES2	JUN/74
34173	3. 2. 1. 1. 1.	EQILBR	JUN/74
34174	3. 2. 1. 1. 1.	BAKLBR	JUN/74
34180	3. 3. 1. 2. 1.	REAVALQRI	JUL/74
34181	3. 3. 1. 2. 1.	REAVECHES	JUL/74
34182	3. 3. 1. 2. 2.	REAEIGVAL	JUL/74
34183	1. 1. 9.	REASCL	APR/74
34184	3. 3. 1. 2. 2.	REAEIG1	JUL/74
34186	3. 3. 1. 2. 1.	REAQRI	JUL/74
34187	3. 3. 1. 2. 2.	REAEIG3	JUL/74
34190	3. 3. 1. 2. 1.	COMVALQRI	JUL/74
34191	3. 3. 1. 2. 1.	COMVECHES	JUL/74
34192	3. 3. 1. 2. 2.	COMEIGVAL	JUL/74
34193	1. 2. 9.	COMSCL	DEC/75
34194	3. 3. 1. 2. 2.	COMEIG1	JUL/74
34200	5. 1. 1. 2. 3.	DAMPED NEWTON	
34202	5. 1. 1. 2. 3.	NEWRAP	

CODE	SECTION	PROCEDURE	MNT/YR
34203	5. 1. 2. 2. 4.	NEWTONMIN	
34210	5. 1. 2. 2. 1.	LINEMIN	DEC/75
34211	5. 1. 2. 2. 1.	RNK1UPD	DEC/75
34212	5. 1. 2. 2. 1.	DAVUPD	DEC/75
34213	5. 1. 2. 2. 1.	FLEUPD	DEC/75
34214	5. 1. 2. 2. 3.	RNK1MIN	DEC/75
34215	5. 1. 2. 2. 3.	FLEMIN	DEC/75
34220	3. 1. 2. 2. 1.	CONJ GRAD	JUN/74
34230	OBSJLETE PROCEDURE	MAXMAT	
34231	3. 1. 1. 1. 1. 1. 1.	GSSSELM	MAY/74
34232	3. 1. 1. 1. 1. 1. 3.	GSSSOL	MAY/74
34235	3. 1. 1. 1. 1. 1. 4.	INV1	MAY/74
34236	3. 1. 1. 1. 1. 1. 4.	GSSINV	MAY/74
34240	3. 1. 1. 1. 1. 1. 1.	ONENRMINV	MAY/74
34241	3. 1. 1. 1. 1. 1. 1.	ERBELM	MAY/74
34242	3. 1. 1. 1. 1. 1. 1.	GSSERB	MAY/74
34243	3. 1. 1. 1. 1. 1. 3.	GSSSOLERB	MAY/74
34244	3. 1. 1. 1. 1. 1. 4.	GSSINVERB	MAY/74
34250	3. 1. 1. 1. 1. 1. 5.	ITISOL	MAY/74
34251	3. 1. 1. 1. 1. 1. 5.	GSSITISOL	MAY/74
34252	3. 1. 1. 1. 1. 1. 1.	GSSNRI	MAY/74
34253	3. 1. 1. 1. 1. 1. 5.	ITISOLERB	MAY/74
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34423	3. 1. 2. 1. 1. 1. 2. 1.	DECTRI	JUN/74
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34426	3. 1. 2. 1. 1. 1. 2. 1.	DECTRIPIV	JUN/74
34427	3. 1. 2. 1. 1. 1. 2. 3.	SOLTRIPIV	JUN/74
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35028	6. 7.	FG	OCT/74
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35038	OBSOLETE PROCEDURE	NONEXPKO	
35040	OBSOLETE PROCEDURE	KO	
35050	6. 6.	INCBETA	SEP/74
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35052	6. 6.	IBQPLUSN	SEP/74
35053	6. 6.	IXQFIX	SEP/74
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35073	OBSOLETE PROCEDURE	NONEXPKA	
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35101	OBSOLETE PROCEDURE	BESSELY	
35102	OBSOLETE PROCEDURE	BESSELI	
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35104	OBSOLETE PROCEDURE	NONEXPBESSELI	
35105	OBSOLETE PROCEDURE	NONEXPBESSELK	
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35113	6. 4. 2.	TANH	SEP/74
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35115	6. 4. 2.	ARCCOSH	SEP/74
35116	6. 4. 2.	ARCTANH	SEP/74
35120	6. 4. 1.	TAN	SEP/74
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35153	6.10. 3.	SPHER BESS K	DEC/78
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35155	6.10. 3.	NONEXP SPHER BESS K	DEC/78
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35161	6. 9. 1.	BESS J1	DEC/78
35162	6. 9. 1.	BESS J	DEC/78
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35166	6. 9. 1.	BESS PQ1	DEC/78
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35171	6. 9. 2.	BESS I1	DEC/78
35172	6. 9. 2.	BESS I	DEC/78
35173	6. 9. 2.	BESS K01	DEC/78
35174	6. 9. 2.	BESS K	DEC/78
35175	6. 9. 2.	NONEXP BESS IO	DEC/78
35176	6. 9. 2.	NONEXP BESS I1	DEC/78
35177	6. 9. 2.	NONEXP BESS I	DEC/78
35178	6. 9. 2.	NONEXP BESS K01	DEC/78
35179	6. 9. 2.	NONEXP BESS K	DEC/78
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35182	6.10. 1.	BESS YAPLUSN	DEC/78
35183	6.10. 1.	BESS PQA01	DEC/78
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IN THIS KEY WORD IN CONTEXT (KWIC) INDEX PROCEDURE NAMES AND KEY WORDS HAVE BEEN ORDERED ALPHABETICALLY.

THE KWIC INDEX IS BASED UPON PROGRAM ABSTRACTS SUCH AS:

32070 #QADRAT (#QUADRATURE) COMPUTES THE #DEFINITE #INTEGRAL OF A  
#FUNCTION OF ONE VARIABLE OVER A FINITE INTERVAL.

THE ABSTRACT COMPRISES THE CODE NUMBER AND A SHORT DESCRIPTION OF THE PROGRAM (ITS NAME, WHAT IT DOES, AND HOW IT DOES IT). THE "IMPORTANT" WORDS (PRECEDED BY A # IN THE ABOVE EXAMPLE) ARE USED AS KEY WORDS IN THE KWIC INDEX. THE FIRST APPEARANCE OF OUR ABOVE EXAMPLE ABSTRACT IN THE KWIC INDEX IS:

QADRAT COMPUTES THE .DEFINITE INTEGRAL OF A FUNCTION OF ONE  
VARIABLE OVER A FINITE INTERVAL. 32070 133

IF THIS PROGRAM (QADRAT) IS OF INTEREST, YOU CAN LOCATE IT BY MEANS OF ITS CODE NUMBER (32070).

IN CASE AN ENTRY IN THE KWIC INDEX IS NOT COMPLETELY READABLE (I.E. TRUNCATED AT AN END OF THE LINE), YOU CAN FIND A COMPLETE LISTING ( BY CODE NUMBER ) OF ALL THE ABSTRACTS FOLLOWING THE KWIC INDEX.

SINCE ALL PROCEDURE NAMES HAVE BEEN INSERTED AS KEYWORDS, THE KWIC INDEX CAN ALSO BE USED TO TRACE A PROCEDURE BY ITS NAME.





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31013 1 INISYMD INITIALIZES A (CO)DIAGONAL OF A SYMMETRIC MATRIX, WHOSE UPPERTRIANGLE IS STORED COLUMNWISE IN A ONE-DIMENSIONAL ARRAY.  
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31021 5 MULROW STORES A CONSTANT MULTIPLIED BY A ROW VECTOR INTO A ROW VECTOR.  
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31034 3 DUPCOLVEC COPIES A VECTOR INTO A COLUMN VECTOR.  
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 31075 269 HSHROWTAM POSTMULTIPLIES A MATRIX BY A HOUSEHOLDER MATRIX, THE VECTOR DEFINING  
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 31093 203 FOUSSER1 EVALUATES A FOURIER SERIES.  
 31094 203 FOUSSER2 EVALUATES A FOURIER SERIES.  
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 31102 271 DPSUB SUBTRACTS TWO SINGLE PRECISION NUMBERS TO A DOUBLE PRECISION  
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 31103 271 DPMUL MULTIPLIES TWO SINGLE PRECISION NUMBERS TO A DOUBLE PRECISION PRODUCT.  
 31104 271 DPDIV DIVIDES TWO SINGLE PRECISION NUMBERS TO A DOUBLE PRECISION QUOTIENT.  
 31105 271 LNGADD ADDS TWO DOUBLE PRECISION NUMBERS.  
 31106 271 LNGSUB SUBTRACTS TWO DOUBLE PRECISION NUMBERS.  
 31107 271 LNGMUL MULTIPLIES TWO DOUBLE PRECISION NUMBERS.  
 31108 271 LNGDIV DIVIDES TWO DOUBLE PRECISION NUMBERS.  
 31109 271 DPPOW COMPUTES THE DOUBLE PRECISION POWER OF A SINGLE PRECISION NUMBER.  
 31110 271 LNGPOW COMPUTES THE DOUBLE PRECISION POWER OF A DOUBLE PRECISION NUMBER.  
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 31132 5 ROWCST MULTIPLIES A ROW VECTOR BY A CONSTANT.  
 31200 201 LNGINTADD COMPUTES THE SUM OF LONG NONNEGATIVE INTEGERS.  
 31201 201 LNGINTSUBTRACT COMPUTES THE DIFFERENCE OF LONG NONNEGATIVE INTEGERS.  
 31202 201 LNGINTMULT COMPUTES THE PRODUCT OF LONG NONNEGATIVE INTEGERS.  
 31203 201 LNGINTDIVIDE COMPUTES THE QUOTIENT WITH REMAINDER OF LONG NONNEGATIVE  
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 31204 201 LNGINTPOWER COMPUTES  $U^{**POWER}$ , WHERE U IS A LONG NONNEGATIVE INTEGER AND POWER  
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 31241 245 TAYPOL EVALUATES THE FIRST K TERMS OF A TAYLOR SERIES.  
 31242 245 NORDERPOL EVALUATES THE FIRST K NORMALIZED DERIVATIVES OF A POLYNOMIAL ( I.E.  
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 31243 245 DERPOL EVALUATES THE FIRST K DERIVATIVES OF A POLYNOMIAL.  
 31248 205 INTCHS COMPUTES THE INDEFINITE INTEGRAL OF A GIVEN CHEBYSHEV SERIES.  
 31250 43 LINTFMPOL TRANSFORMS A POLYNOMIAL IN X INTO A POLYNOMIAL IN Y ( $Y = AX + B$ ).  
 31252 313 GSSWTSSYM CALCULATES THE GAUSSIAN WEIGHTS OF A WEIGHT FUNCTION, THE RECURRENCE  
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- 31254 313 RECCOF CALCULATES RECURRENCE COEFFICIENTS OF AN ORTHOGONAL POLYNOMIAL, A WEIGHT FUNCTION BEING GIVEN.
- 31362 211 ALLZERORTPOL CALCULATES ALL ZEROS OF AN ORTHOGONAL POLYNOMIAL.
- 31363 211 LUPZERORTPOL CALCULATES A NUMBER OF ADJACENT UPPER OR LOWER ZEROS OF AN ORTHOGONAL POLYNOMIAL.
- 31364 211 SELZERORTPOL CALCULATES A NUMBER OF ADJACENT ZEROS OF AN ORTHOGONAL POLYNOMIAL.
- 31370 211 ALLJACZER CALCULATES THE ZEROS OF A JACOBIAN POLYNOMIAL.
- 31371 211 ALLLAGZER CALCULATES THE ZEROS OF A LAGUERRE POLYNOMIAL.
- 31425 291 GSSJACWGHTS COMPUTES THE ABSCISSAE AND WEIGHTS FOR GAUSS- JACOBI QUADRATURE.
- 31427 291 GSSLAGWGHTS COMPUTES THE ABSCISSAE AND WEIGHTS FOR GAUSS- LAGRANGE QUADRATURE.
- 31500 15 FULMATVEC CALCULATES THE PRODUCT  $A * B$ , WHERE A IS A GIVEN MATRIX AND B IS A VECTOR.
- 31501 15 FULTAMVEC CALCULATES THE PRODUCT  $A' * B$ , WHERE A' IS THE TRANSPOSED OF THE MATRIX A AND B IS A VECTOR.
- 31502 15 FULSYMATVEC CALCULATES THE PRODUCT  $A * B$ , WHERE A IS A SYMMETRIC MATRIX, WHOSE UPPERTRIANGLE IS STORED COLUMNWISE IN A ONE-DIMENSIONAL ARRAY AND B IS A VECTOR.
- 31503 15 RESVEC CALCULATES THE RESIDUAL VECTOR  $A * B + X * C$ , WHERE A IS A GIVEN MATRIX, B AND C ARE VECTORS AND X IS A SCALAR.
- 31504 15 SYMRESVEC CALCULATES THE RESIDUAL VECTOR  $A * B + X * C$ , WHERE A IS A SYMMETRIC MATRIX, WHOSE UPPERTRIANGLE IS STORED COLUMNWISE IN A ONE-DIMENSIONAL ARRAY, B AND C ARE VECTORS AND X IS A SCALAR.
- 31505 285 LNGFULMATVEC CALCULATES BY DOUBLE PRECISION ARITHMETIC THE PRODUCT  $A * B$ , WHERE A IS A GIVEN MATRIX AND B IS A VECTOR.
- 31506 285 LNGFULTAMVEC CALCULATES BY DOUBLE PRECISION ARITHMETIC THE PRODUCT  $A' * B$ , WHERE A' IS THE TRANSPOSED OF THE MATRIX A AND B IS A VECTOR.
- 31507 285 LNGFULSYMATVEC CALCULATES BY DOUBLE PRECISION ARITHMETIC THE PRODUCT  $A * B$ , WHERE A IS A SYMMETRIC MATRIX, WHOSE UPPERTRIANGLE IS STORED COLUMNWISE IN A ONE-DIMENSIONAL ARRAY AND B IS A VECTOR.
- 31508 285 LNGRESVEC CALCULATES BY DOUBLE PRECISION ARITHMETIC THE RESIDUAL VECTOR  $A * B + X * C$ , WHERE A IS A GIVEN MATRIX, B AND C ARE VECTORS AND X IS A SCALAR.
- 31509 285 LNGSYMRESVEC CALCULATES BY DOUBLE PRECISION ARITHMETIC THE RESIDUAL VECTOR  $A * B + X * C$ , WHERE A IS A SYMMETRIC MATRIX, WHOSE UPPERTRIANGLE IS STORED COLUMNWISE IN A ONE-DIMENSIONAL ARRAY, B AND C ARE VECTORS AND X IS A SCALAR.
- 32010 131 EULER PERFORMS THE SUMMATION OF AN ALTERNATING INFINITE SERIES.
- 32020 131 SUMPOSSERIES PERFORMS THE SUMMATION OF A INFINITE SERIES WITH POSITIVE MONOTONICALLY DECREASING TERMS USING THE VAN WIJNGAARDEN TRANSFORMATION.
- 32051 135 INTEGRAL CALCULATES THE DEFINITE INTEGRAL OF A FUNCTION OF ONE VARIABLE OVER A FINITE OR INFINITE INTERVAL OR OVER A NUMBER OF CONSECUTIVE INTERVALS.
- 32070 133 QADRAT COMPUTES THE DEFINITE INTEGRAL OF A FUNCTION OF ONE VARIABLE OVER A FINITE INTERVAL.
- 32075 257 TRICUB COMPUTES THE DEFINITE INTEGRAL OF A FUNCTION OF TWO VARIABLES OVER A TRIANGULAR DOMAIN.
- 33010 141 RK1 SOLVES A SINGLE 1ST ORDER DIFFERENTIAL EQUATION BY MEANS OF A 5TH ORDER RUNGE-KUTTA METHOD.
- 33012 171 RK2 INTEGRATES A SINGLE 2ND ORDER DIFFERENTIAL EQUATION ( INITIAL VALUE PROBLEM ) BY MEANS OF A 5TH ORDER RUNGE-KUTTA METHOD.
- 33013 173 RK2N SOLVES A SYSTEM OF 2ND ORDER DIFFERENTIAL EQUATIONS ( INITIAL VALUE PROBLEM ) BY MEANS OF A 5TH ORDER RUNGE-KUTTA METHOD.
- 33014 175 RK3 SOLVES A SINGLE 2ND ORDER DIFFERENTIAL EQUATION ( INITIAL VALUE PROBLEM ) BY MEANS OF A 5TH ORDER RUNGE-KUTTA METHOD; THIS METHOD CAN ONLY BE USED IF THE RIGHT HAND SIDE OF THE DIFFERENTIAL EQUATION DOES NOT DEPEND ON Y'.
- 33015 177 RK3N SOLVES A SYSTEM OF 2ND ORDER DIFFERENTIAL EQUATIONS ( INITIAL VALUE

- PROBLEM ) BY MEANS OF A 5TH ORDER RUNGE-KUTTA METHOD; THIS METHOD CAN ONLY BE USED IF THE RIGHT HAND SIDE OF THE DIFFERENTIAL EQUATIONS DOES NOT DEPEND ON Y'.
- 33016 145 RK4A SOLVES A SINGLE 1ST ORDER DIFFERENTIAL EQUATION BY MEANS OF A 5TH ORDER RUNGE-KUTTA METHOD; THE INTEGRATION IS TERMINATED AS SOON AS A CONDITION ON X AND Y, WHICH IS SUPPLIED BY THE USER, IS SATISFIED.
- 33017 147 RK4NA SOLVES A SYSTEM OF 1ST ORDER DIFFERENTIAL EQUATIONS ( INITIAL VALUE PROBLEM ) BY MEANS OF A 5TH ORDER RUNGE-KUTTA METHOD; THE INTEGRATION IS TERMINATED AS SOON AS A CONDITION ON XC0J,...,XCNJ , SUPPLIED BY THE USER, IS SATISFIED.
- 33018 149 RK5NA SOLVES A SYSTEM OF 1ST ORDER DIFFERENTIAL EQUATIONS ( INITIAL VALUE PROBLEM ) BY MEANS OF A 5TH ORDER RUNGE-KUTTA METHOD; THE ARC LENGTH IS INTRODUCED AS AN INTEGRATION VARIABLE; THE INTEGRATION IS TERMINATED AS SOON AS A CONDITION ON XC0J,...,XCNJ , SUPPLIED BY THE USER, IS SATISFIED.
- 33033 143 RKE SOLVES A SYSTEM OF 1ST ORDER DIFFERENTIAL EQUATIONS ( INITIAL VALUE PROBLEM ) BY MEANS OF A 5TH ORDER RUNGE-KUTTA METHOD.
- 33040 167 MODIFIED TAYLOR SOLVES A SYSTEM OF 1ST ORDER DIFFERENTIAL EQUATIONS ( INITIAL VALUE PROBLEM ) BY MEANS OF A 1ST, 2ND OR 3RD ORDER ONE-STEP TAYLOR METHOD; THIS METHOD CAN BE USED TO SOLVE LARGE AND SPARSE SYSTEMS, PROVIDED HIGHER ORDER DERIVATIVES CAN EASILY BE OBTAINED.
- 33050 169 EXPONENTIALLY FITTED TAYLOR SOLVES A SYSTEM OF 1ST ORDER DIFFERENTIAL EQUATIONS ( INITIAL VALUE PROBLEM ) BY MEANS OF A VARIABLE ORDER TAYLOR METHOD; THIS METHOD CAN BE USED TO SOLVE STIFF SYSTEMS, WITH KNOWN EIGEN VALUE SPECTRUM, PROVIDED HIGHER ORDER DERIVATIVES CAN EASILY BE OBTAINED.
- 33061 155 ARK SOLVES A SYSTEM OF 1ST ORDER DIFFERENTIAL EQUATIONS ( INITIAL VALUE PROBLEM ) BY MEANS OF A STABILIZED RUNGE-KUTTA METHOD WITH LIMITED STORAGE REQUIREMENTS.
- 33066 295 ARKMAT SOLVES A SYSTEM OF 1ST ORDER DIFFERENTIAL EQUATIONS ( INITIAL BOUNDARY-VALUE PROBLEM ) BY MEANS OF A STABILIZED RUNGE-KUTTA METHOD, IN PARTICULAR SUITABLE FOR SYSTEMS ARISING FROM TWO-DIMENSIONAL TIME-DEPENDENT PARTIAL DIFFERENTIAL EQUATIONS.
- 33070 157 EFRK SOLVES A SYSTEM OF 1ST ORDER DIFFERENTIAL EQUATIONS ( INITIAL VALUE PROBLEM ) BY MEANS OF A 1ST, 2ND OR 3RD ORDER, EXPONENTIALLY FITTED RUNGE-KUTTA METHOD; AUTOMATIC STEPSIZE CONTROL IS NOT PROVIDED; THIS METHOD CAN BE USED TO SOLVE STIFF SYSTEMS WITH KNOWN EIGENVALUE SPECTRUM.
- 33080 151 MULTISTEP SOLVES A SYSTEM OF 1ST ORDER DIFFERENTIAL EQUATIONS ( INITIAL VALUE PROBLEM ) BY MEANS OF A VARIABLE ORDER MULTISTEP METHOD ADAMS-MOULTON, ADAMS-BASHFORTH OR GEAR'S METHOD; THE ORDER OF ACCURACY IS AUTOMATIC, UP TO 5TH ORDER; THIS METHOD IS SUITABLE FOR STIFF SYSTEMS.
- 33120 161 EFERK SOLVES AN AUTONOMOUS SYSTEM OF 1ST ORDER DIFFERENTIAL EQUATIONS ( INITIAL VALUE PROBLEM ) BY MEANS OF AN EXPONENTIALLY FITTED, 3RD ORDER RUNGE-KUTTA METHOD; THIS METHOD CAN BE USED TO SOLVE STIFF SYSTEMS WITH KNOWN EIGENVALUE SPECTRUM.
- 33131 165 LINIGER2 SOLVES AN AUTONOMOUS SYSTEM OF 1ST ORDER DIFFERENTIAL EQUATIONS ( INITIAL VALUE PROBLEM ) BY MEANS OF AN IMPLICIT, EXPONENTIALLY FITTED 1ST ORDER ONE-STEP METHOD; AUTOMATIC STEP-SIZE CONTROL IS NOT PROVIDED; THIS METHOD CAN BE USED TO SOLVE STIFF SYSTEMS.
- 33132 221 LINIGER1VS SOLVES AN AUTONOMOUS SYSTEM OF 1ST ORDER DIFFERENTIAL EQUATIONS ( INITIAL VALUE PROBLEM ) BY MEANS OF AN IMPLICIT, EXPONENTIALLY FITTED 1ST ORDER ONE-STEP METHOD; THIS METHOD CAN BE USED TO SOLVE STIFF SYSTEMS.
- 33135 231 IMPEX SOLVES AN AUTONOMOUS SYSTEM OF 1ST ORDER DIFFERENTIAL EQUATIONS ( INITIAL VALUE PROBLEM ) BY MEANS OF THE IMPLICIT MIDPOINT RULE WITH SMOOTHING AND EXTRAPOLATION; THIS METHOD IS SUITABLE FOR THE INTEGRATION OF STIFF DIFFERENTIAL EQUATIONS.
- 33160 159 EFSIRK SOLVES AN AUTONOMOUS SYSTEM OF 1ST ORDER DIFFERENTIAL EQUATIONS ( INITIAL VALUE PROBLEM ) BY MEANS OF A 3RD ORDER, EXPONENTIALLY FITTED,

SEMI-IMPLICIT RUNGE-KUTTA METHOD; THIS METHOD CAN BE USED TO SOLVE STIFF SYSTEMS.

33170 225 RICHARDSON SOLVES A SYSTEM OF LINEAR EQUATIONS WITH POSITIVE REAL EIGENVALUES ( ELLIPTIC BOUNDARY VALUE PROBLEM ) BY MEANS OF A NON-STATIONARY 2ND ORDER ITERATIVE METHOD.

33171 225 ELIMINATION SOLVES A SYSTEM OF LINEAR EQUATIONS WITH POSITIVE REAL EIGENVALUES ( ELLIPTIC BOUNDARY VALUE PROBLEM ) BY MEANS OF A NON-STATIONARY 2ND ORDER ITERATIVE METHOD, WHICH IS AN ACCELERATION OF RICHARDSON'S METHOD.

33180 153 DIFFSYS SOLVES A SYSTEM OF 1ST ORDER DIFFERENTIAL EQUATIONS ( INITIAL VALUE PROBLEM ); BY EXTRAPOLATION, APPLIED TO LOW ORDER RESULTS, A HIGH ORDER OF ACCURACY IS OBTAINED; THIS METHOD IS SUITABLE FOR SMOOTH PROBLEMS WHEN HIGH ACCURACY IS REQUIRED.

33191 223 GMS SOLVES AN AUTONOMOUS SYSTEM OF 1ST ORDER DIFFERENTIAL EQUATIONS ( INITIAL VALUE PROBLEM ) BY MEANS OF A 3RD ORDER MULTISTEP METHOD; THIS METHOD CAN BE USED TO SOLVE STIFF SYSTEMS.

33300 261 FEMLAGSYM SOLVES A LINEAR TWO-POINT BOUNDARY-VALUE PROBLEM FOR A SECOND ORDER SELF-ADJOINT DIFFERENTIAL EQUATION BY A RITZ- GALERKIN METHOD.

33301 261 FEMLAG SOLVES A LINEAR TWO-POINT BOUNDARY-VALUE PROBLEM FOR A SECOND ORDER SELF-ADJOINT DIFFERENTIAL EQUATION BY A RITZ- GALERKIN METHOD; THE COEFFICIENT OF Y' IS SUPPOSED TO BE UNITY.

33302 263 FEMLAGSKEW SOLVES A LINEAR TWO-POINT BOUNDARY-VALUE PROBLEM FOR A SECOND ORDER DIFFERENTIAL EQUATION BY A RITZ- GALERKIN METHOD.

33303 265 FEMHERMSYM SOLVES A LINEAR TWO-POINT BOUNDARY-VALUE PROBLEM FOR A FOURTH ORDER SELF-ADJOINT DIFFERENTIAL EQUATION WITH DIRICHLET BOUNDARY CONDITIONS BY A RITZ- GALERKIN METHOD.

33308 261 FEMLAGSPHER SOLVES A LINEAR TWO-POINT BOUNDARY-VALUE PROBLEM FOR A SECOND ORDER SELF-ADJOINT DIFFERENTIAL EQUATION WITH SPHERICAL COORDINATES BY A RITZ-GALERKIN METHOD.

33314 317 NONLINFEMLAGSKEW SOLVES A NONLINEAR TWO-POINT BOUNDARY-VALUE PROBLEM FOR A SECOND ORDER DIFFERENTIAL EQUATION WITH SPHERICAL COORDINATES BY A RITZ-GALERKIN METHOD AND NEWTON ITERATION.

34010 7 VECVEC := SCALAR PRODUCT OF A VECTOR AND A VECTOR.

34011 7 MATVEC := SCALAR PRODUCT OF A ROW VECTOR AND A VECTOR.

34012 7 TAMVEC := SCALAR PRODUCT OF A COLUMN VECTOR AND A VECTOR.

34013 7 MATMAT := SCALAR PRODUCT OF A ROW VECTOR AND A COLUMN VECTOR.

34014 7 TAMMAT := SCALAR PRODUCT OF A COLUMN VECTOR AND A COLUMN VECTOR.

34015 7 MATTAM := SCALAR PRODUCT OF A ROW VECTOR AND A ROW VECTOR.

34016 7 SEQVEC := SCALAR PRODUCT OF TWO VECTORS GIVEN IN ONE-DIMENSIONAL ARRAYS, WHERE THE MUTUAL SPACINGS BETWEEN THE INDICES OF THE 1ST VECTOR CHANGE LINEARLY.

34017 7 SCAPRD1 := SCALAR PRODUCT OF TWO VECTORS GIVEN IN ONE-DIMENSIONAL ARRAYS, WHERE THE SPACINGS OF BOTH VECTORS ARE CONSTANT.

34018 7 SYMMATVEC := SCALAR PRODUCT OF A VECTOR AND A ROW OF A SYMMETRIC MATRIX, WHOSE UPPERTRIANGLE IS GIVEN COLUMNWISE IN A ONE-DIMENSIONAL ARRAY.

34020 9 ELMVEC ADDS A CONSTANT TIMES A VECTOR TO A VECTOR.

34021 9 ELMVECCOL ADDS A CONSTANT TIMES A COLUMN VECTOR TO A VECTOR.

34022 9 ELMCOLVEC ADDS A CONSTANT TIMES A VECTOR TO A COLUMN VECTOR.

34023 9 ELMCOL ADDS A CONSTANT TIMES A COLUMN VECTOR TO A COLUMN VECTOR.

34024 9 ELMROW ADDS A CONSTANT TIMES A ROW VECTOR TO A ROW VECTOR.

34025 9 MAXELMROW ADDS A CONSTANT TIMES A ROW VECTOR TO A ROW VECTOR, MAXELMROW:=THE SUBSCRIPT OF AN ELEMENT OF THE NEW ROW VECTOR WHICH IS OF MAXIMUM ABSOLUTE VALUE.

34026 9 ELMVECREW ADDS A CONSTANT TIMES A ROW VECTOR TO A VECTOR.

34027 9 ELMROWVEC ADDS A CONSTANT TIMES A VECTOR TO A ROW VECTOR.

34028 9 ELMROWCOL ADDS A CONSTANT TIMES A COLUMN VECTOR TO A ROW VECTOR.

34029 9 ELMCOLROW ADDS A CONSTANT TIMES A ROW VECTOR TO A COLUMN VECTOR.

34030 11 ICHVEC INTERCHANGES TWO VECTORS GIVEN IN ARRAY ACL:UJ AND ARRAY ALSHIFT + L ;

SHIFT + UJ.

34031 11 ICHCOL INTERCHANGES TWO COLUMNS OF A MATRIX.

34032 11 ICHROW INTERCHANGES TWO ROWS OF MATRIX.

34033 11 ICHROWCOL INTERCHANGES A ROW AND A COLUMN OF A MATRIX.

34034 11 ICHSEQVEC INTERCHANGES A ROW AND A COLUMN OF AN UPPERTRIANGULAR MATRIX, WHICH IS STORED COLUMNWISE IN A ONE-DIMENSIONAL ARRAY.

34035 11 ICHSEQ INTERCHANGES TWO COLUMNS OF AN UPPERTRIANGULAR MATRIX, WHICH IS STORED COLUMNWISE IN A ONE-DIMENSIONAL ARRAY.

34040 13 ROTCOL REPLACES TWO COLUMN VECTORS X AND Y BY TWO VECTORS  $CX + SY$  AND  $CY - SX$ .

34041 13 ROTROW REPLACES TWO ROW VECTORS X AND Y BY TWO VECTORS  $CX + SY$  AND  $CY - SX$ .

34051 49 SOL SOLVES THE SYSTEM OF LINEAR EQUATIONS WHOSE MATRIX HAS BEEN TRIANGULARLY DECOMPOSED BY DEC.

34053 51 INV CALCULATES THE INVERSE OF A MATRIX THAT HAS BEEN TRIANGULARLY DECOMPOSED BY DEC.

34061 49 SOLELM SOLVES A SYSTEM OF LINEAR EQUATIONS WHOSE MATRIX HAS BEEN TRIANGULARLY DECOMPOSED BY GSSELM OR GSSERB.

34071 79 SOLBND SOLVES A SYSTEM OF LINEAR EQUATIONS, THE MATRIX BEING DECOMPOSED BY DECBND.

34131 65 LSQSOL SOLVES A LINEAR LEAST SQUARES PROBLEM IF THE COEFFICIENT MATRIX HAS BEEN DECOMPOSED BY LSQORTDEC.

34132 63 LSQDGLINV CALCULATES THE DIAGONAL ELEMENTS OF THE INVERSE OF  $M'M$ , WHERE M IS THE COEFFICIENT MATRIX OF A LINEAR LEAST SQUARES PROBLEM.

34134 63 LSQORTDEC DELIVERS THE HOUSEHOLDER TRIANGULARIZATION WITH COLUMN INTERCHANGES OF THE MATRIX OF A LINEAR LEAST SQUARES PROBLEM.

34135 65 LSQORTDECSOL SOLVES A LINEAR LEAST SQUARES PROBLEM BY HOUSEHOLDER TRIANGULARIZATION WITH COLUMN INTERCHANGES AND CALCULATES THE DIAGONAL OF THE INVERSE OF  $M'M$ , WHERE M IS THE COEFFICIENT MATRIX.

34136 207 LSQINV CALCULATES THE INVERSE OF THE MATRIX S'S, WHERE S IS THE COEFFICIENT MATRIX OF A LINEAR LEAST SQUARES PROBLEM.

34137 309 LSQDECOMP COMPUTES THE QR- DECOMPOSITION OF A LINEAR LEAST SQUARES PROBLEM WITH LINEAR CONSTRAINTS.

34138 309 LSQREFSOL SOLVES A LINEAR LEAST SQUARES PROBLEM WITH LINEAR CONSTRAINTS, IF THE MATRIX HAS BEEN DECOMPOSED BY LSQDECOMP.

34140 101 TFMSYMTRI2 TRANSFORMS A REAL SYMMETRIC MATRIX INTO A SIMILAR TRIDIAGONAL ONE BY MEANS OF HOUSEHOLDER'S TRANSFORMATION.

34141 101 BAKSYMTRI2 PERFORMS THE BACK TRANSFORMATION CORRESPONDING TO TFMSYMTRI2.

34142 101 TFMPEVEC IN COMBINATION WITH TFMSYMTRI2 CALCULATES THE TRANSFORMING MATRIX.

34143 101 TFMSYMTRI1 TRANSFORMS A REAL SYMMETRIC MATRIX INTO A SIMILAR TRIDIAGONAL ONE BY MEANS OF HOUSEHOLDER'S TRANSFORMATION.

34144 101 BAKSYMTRI1 PERFORMS THE BACK TRANSFORMATION CORRESPONDING TO TFMSYMTRI1.

34150 215 ZEROIN FINDS ( IN A GIVEN INTERVAL ) A ZERO OF A FUNCTION OF ONE VARIABLE.

34151 111 VALSYMTRI CALCULATES ALL, OR SOME CONSECUTIVE, EIGENVALUES OF A SYMMETRIC TRIDIAGONAL MATRIX BY MEANS OF LINEAR INTERPOLATION USING A STURM SEQUENCE.

34152 111 VECSYMTRI CALCULATES EIGENVECTORS OF A SYMMETRIC TRIDIAGONAL MATRIX BY MEANS OF INVERSE ITERATION.

34153 113 EIGVALSYM2 CALCULATES ALL ( OR SOME ) EIGENVALUES OF A SYMMETRIC MATRIX USING LINEAR INTERPOLATION OF A FUNCTION DERIVED FROM A STURM SEQUENCE.

34154 113 EIGSYM2 CALCULATES EIGENVALUES AND EIGENVECTORS BY MEANS OF INVERSE ITERATION.

34155 113 EIGVALSYM1 CALCULATES ALL ( OR SOME ) EIGENVALUES OF A SYMMETRIC MATRIX USING LINEAR INTERPOLATION OF A FUNCTION DERIVED FROM A STURM SEQUENCE.

34156 113 EIGSYM1 CALCULATES EIGENVALUES AND EIGENVECTORS BY MEANS OF INVERSE ITERATION.

34160 111 QRVALSYMTRI CALCULATES THE EIGENVALUES OF A SYMMETRIC TRIDIAGONAL MATRIX BY MEANS OF QR ITERATION.

34161 111 QRISYMTRI CALCULATES THE EIGENVALUES AND EIGENVECTORS OF A SYMMETRIC TRIDIAGONAL MATRIX BY MEANS OF QR ITERATION.

34162 113 QRIVALSYM2 CALCULATES THE EIGENVALUES OF A SYMMETRIC MATRIX BY MEANS OF QR ITERATION.

34163 113 QRISYM CALCULATES ALL EIGENVALUES AND EIGENVECTORS OF A SYMMETRIC MATRIX BY MEANS OF QR ITERATION.

34164 113 QRIVALSYM1 CALCULATES THE EIGENVALUES OF A SYMMETRIC MATRIX BY MEANS OF QR ITERATION.

34170 103 TFMREAHES TRANSFORMS A MATRIX INTO A SIMILAR UPPER- HESSENBERG MATRIX BY MEANS OF WILKINSON'S TRANSFORMATION.

34171 103 BAKREAHES1 PERFORMS THE BACK TRANSFORMATION ( ON A VECTOR ) CORRESPONDING TO TFMREAHES.

34172 103 BAKREAHES2 PERFORMS THE BACK TRANSFORMATION ( ON COLUMNS ) CORRESPONDING TO TFMREAHES.

34173 97 EQUILBR EQUILIBRATES A MATRIX BY MEANS OF A DIAGONAL SIMILARITY TRANSFORMATION.

34174 97 BAKLBR PERFORMS THE BACK TRANSFORMATION CORRESPONDING TO EQUILBR.

34180 115 REAVALQRI CALCULATES THE EIGENVALUES OF A REAL UPPER- HESSENBERG MATRIX, PROVIDED THAT ALL EIGENVALUES ARE REAL, BY MEANS OF SINGLE QR ITERATION.

34181 115 REAVECHES CALCULATES AN EIGENVECTOR CORRESPONDING TO A GIVEN REAL EIGENVALUE OF A REAL UPPER- HESSENBERG MATRIX BY MEANS OF INVERSE ITERATION.

34182 117 REAEIGVAL CALCULATES THE EIGENVALUES OF A MATRIX, PROVIDED THAT ALL EIGENVALUES ARE REAL.

34183 17 REASCL NORMALIZES THE COLUMNS OF A TWO-DIMENSIONAL ARRAY.

34184 117 REAEIG1 CALCULATES THE EIGENVECTORS AND EIGENVALUES OF A MATRIX, PROVIDED THAT THEY ARE ALL REAL.

34186 115 REAQRI CALCULATES ALL EIGENVALUES AND EIGENVECTORS OF A REAL UPPER- HESSENBERG MATRIX, PROVIDED THAT ALL EIGENVALUES ARE REAL, BY MEANS OF SINGLE QR ITERATION.

34187 117 REAEIG3 CALCULATES THE EIGENVECTORS AND EIGENVALUES OF A MATRIX, PROVIDED THAT THEY ARE ALL REAL.

34190 115 COMVALQRI CALCULATES THE REAL AND COMPLEX EIGENVALUES OF A REAL UPPER- HESSENBERG MATRIX BY MEANS OF DOUBLE QR ITERATION.

34191 115 COMVECHES CALCULATES THE EIGENVECTOR CORRESPONDING TO A GIVEN COMPLEX EIGENVALUE OF A REAL UPPER- HESSENBERG MATRIX BY MEANS OF INVERSE ITERATION.

34192 117 COMEIGVAL CALCULATES THE EIGENVALUES OF A MATRIX.

34193 29 COMSCL NORMALIZES REAL AND COMPLEX EIGENVECTORS.

34194 117 COMEIG1 CALCULATES THE EIGENVALUES AND EIGENVECTORS OF A MATRIX.

34210 139 LINEMIN MINIMIZES A FUNCTION OF SEVERAL VARIABLES IN A GIVEN DIRECTION.

34211 139 RNKIUPD ADDS A RANK-1 MATRIX TO A SYMMETRIC MATRIX.

34212 139 DAVUPD ADDS A RANK-2 MATRIX TO A SYMMETRIC MATRIX.

34213 139 FLEUPD ADDS A RANK-2 MATRIX TO A SYMMETRIC MATRIX.

34214 19 RNK1MIN MINIMIZES A FUNCTION OF SEVERAL VARIABLES.

34215 19 FLEMIN MINIMIZES A FUNCTION OF SEVERAL VARIABLES.

34220 95 CONJ GRAD SOLVES A POSITIVE DEFINITE SYMMETRIC SYSTEM OF LINEAR EQUATIONS BY THE METHOD OF CONJUGATE GRADIENTS.

34231 45 GSSELM PERFORMS A TRIANGULAR DECOMPOSITION WITH A COMBINATION OF PARTIAL AND COMPLETE PIVOTING.

34232 49 GSSSOL SOLVES A SYSTEM OF LINEAR EQUATIONS.

34235 51 INV1 CALCULATES THE INVERSE OF A MATRIX THAT HAS BEEN TRIANGULARLY DECOMPOSED BY GSSELM OR GSSERB. THE 1-NORM OF THE INVERSE MATRIX MIGHT ALSO BE CALCULATED.

34236 51 GSSINV CALCULATES THE INVERSE OF A MATRIX.

34240 45 ONENRMINV CALCULATES THE 1- NORM OF THE INVERSE OF A MATRIX WHOSE TRIANGULARLY DECOMPOSED FORM IS DELIVERED BY GSSELM.

34241 45 ERBELM CALCULATES A ROUGH UPPERBOUND FOR THE ERROR IN THE SOLUTION OF A SYSTEM

- OF LINEAR EQUATIONS WHOSE MATRIX IS TRIANGULARLY DECOMPOSED BY GSSELM.
- 34242 45 GSSERB PERFORMS A TRIANGULAR DECOMPOSITION OF THE MATRIX OF A SYSTEM OF LINEAR EQUATIONS AND CALCULATES AN UPPERBOUND FOR THE RELATIVE ERROR IN THE SOLUTION OF THAT SYSTEM.
- 34243 49 GSSSOLERB SOLVES A SYSTEM OF LINEAR EQUATIONS AND CALCULATES A ROUGH UPPERBOUND FOR THE RELATIVE ERROR IN THE CALCULATED SOLUTION.
- 34244 51 GSSINVERB CALCULATES THE INVERSE OF A MATRIX AND 1- NORM, AN UPPERBOUND FOR THE ERROR IN THE INVERSE MATRIX IS ALSO GIVEN.
- 34250 53 ITISOL SOLVES A SYSTEM OF LINEAR EQUATIONS WHOSE MATRIX HAS BEEN TRIANGULARLY DECOMPOSED BY GSSELM OR GSSERB. THIS SOLUTION IS IMPROVED ITERATIVELY.
- 34251 53 GSSITISOL SOLVES A SYSTEM OF LINEAR EQUATIONS AND THE SOLUTION IS IMPROVED ITERATIVELY.
- 34252 45 GSSNRI PERFORMS A TRIANGULAR DECOMPOSITION AND CALCULATES THE 1- NORM OF THE INVERSE MATRIX.
- 34253 53 ITISOLERB SOLVES A SYSTEM OF LINEAR EQUATIONS WHOSE MATRIX HAS TRIANGULARLY DECOMPOSED BY GSSNRI; THIS SOLUTION IS IMPROVED ITERATIVELY AN UPPERBOUND FOR THE ERROR IN THE SOLUTION IS CALCULATED.
- 34254 53 GSSITISOLERB SOLVES A SYSTEM OF LINEAR EQUATIONS; THIS SOLUTION IS IMPROVED ITERATIVELY AND AN UPPERBOUND FOR THE ERROR IN THE SOLUTION IS CALCULATED.
- 34260 109 HSHREABID TRANSFORMS A MATRIX TO BIDIAGONAL FORM, BY PREMULTIPLYING AND POSTMULTIPLYING WITH ORTHOGONAL MATRICES.
- 34261 109 PSTTFMMAT CALCULATES THE POSTMULTIPLYING MATRIX FROM THE DATA GENERATED BY HSHREABID.
- 34262 109 PRETFMMAT CALCULATES THE PREMULTIPLYING MATRIX FROM THE DATA GENERATED BY HSHREABID.
- 34270 125 QRISNGVALBID CALCULATES THE SINGULAR VALUES OF A BIDIAGONAL MATRIX.
- 34271 125 QRISNGVALDECBID CALCULATES THE SINGULAR VALUES DECOMPOSITION OF A MATRIX OF WHICH THE BIDIAGONAL AND THE PRE- AND POSTMULTIPLYING MATRICES ARE GIVEN.
- 34272 127 QRISNGVAL CALCULATES THE SINGULAR VALUES OF A GIVEN MATRIX.
- 34273 127 QRISNGVALDEC CALCULATES THE SINGULAR VALUES DECOMPOSITION  $U * S * V'$ , WITH U AND V ORTHOGONAL AND S POSITIVE DIAGONAL.
- 34280 67 SOLSDOVR SOLVES AN OVERDETERMINED SYSTEM OF LINEAR EQUATIONS, MULTIPLYING THE RIGHT-HAND SIDE BY THE PSEUDO-INVERSE OF THE GIVEN MATRIX.
- 34281 67 SOLOVR CALCULATES THE SINGULAR VALUES DECOMPOSITION AND SOLVES AN OVERDETERMINED SYSTEM OF LINEAR EQUATIONS.
- 34282 69 SOLSDUND SOLVES AN UNDERDETERMINED SYSTEM OF LINEAR EQUATIONS, MULTIPLYING THE RIGHT-HAND SIDE BY THE PSEUDO-INVERSE OF THE GIVEN MATRIX.
- 34283 69 SOLUND CALCULATES THE SINGULAR VALUES DECOMPOSITION AND SOLVES AN UNDERDETERMINED SYSTEM OF LINEAR EQUATIONS.
- 34284 71 HOMSOLSVD SOLVES THE HOMOGENEOUS SYSTEM OF LINEAR EQUATIONS  $A * X = 0$  AND  $X' * A = 0$ , WHERE "A" DENOTES A MATRIX AND "X" A VECTOR; ( THE SINGULAR VALUE DECOMPOSITION BEING GIVEN ).
- 34285 71 HOMSOL SOLVES THE HOMOGENEOUS SYSTEM OF LINEAR EQUATIONS OF EQUATIONS  $A * X = 0$  AND  $X' * A = 0$ , WHERE "A" DENOTES A MATRIX AND "X" A VECTOR.
- 34286 73 PSDINVSVD CALCULATES THE PSEUDO-INVERSE OF A MATRIX; ( THE SINGULAR VALUE DECOMPOSITION BEING GIVEN ).
- 34287 73 PSDINV CALCULATES THE PSEUDO-INVERSE OF A MATRIX.
- 34291 303 DECSYM2 CALCULATES THE SYMMETRIC DECOMPOSITION OF A SYMMETRIC MATRIX.
- 34292 307 SOLSYM2 SOLVES A SYMMETRIC SYSTEM OF LINEAR EQUATIONS IF THE COEFFICIENT MATRIX HAS BEEN DECOMPOSED BY DECSYM2 OR DECSOLSYM2.
- 34293 307 DECSOLSYM2 SOLVES A SYMMETRIC SYSTEM OF LINEAR EQUATIONS BY SYMMETRIC DECOMPOSITION.
- 34294 305 DETERMSYM2 CALCULATES THE DETERMINANT OF A SYMMETRIC MATRIX, THE SYMMETRIC DECOMPOSITION BEING GIVEN.
- 34300 45 DEC PERFORMS A TRIANGULAR DECOMPOSITION WITH PARTIAL PIVOTING.
- 34301 49 DECSOL SOLVES A SYSTEM OF LINEAR EQUATIONS WHOSE ORDER IS SMALL RELATIVE TO THE

- NUMBER OF BINARY DIGITS IN THE NUMBER REPRESENTATION.
- 34302 51 DECINV CALCULATES THE INVERSE OF A MATRIX WHOSE ORDER IS SMALL RELATIVE TO THE NUMBER OF BINARY DIGITS IN THE NUMBER REPRESENTATION.
- 34303 47 DETERM CALCULATES THE DETERMINANT OF A TRIANGULARLY DECOMPOSED MATRIX.
- 34310 55 CHLDEC2 CALCULATES THE CHOLESKY DECOMPOSITION OF A POSITIVE DEFINITE SYMMETRIC MATRIX WHOSE UPPER TRIANGLE IS GIVEN IN A TWO-DIMENSIONAL ARRAY.
- 34311 55 CHLDEC1 CALCULATES THE CHOLESKY DECOMPOSITION OF A POSITIVE DEFINITE SYMMETRIC MATRIX WHOSE UPPER TRIANGLE IS GIVEN COLUMNWISE IN A ONE-DIMENSIONAL ARRAY.
- 34312 57 CHLDETERM2 CALCULATES OF THE DETERMINANT OF A POSITIVE DEFINITE SYMMETRIC MATRIX, THE CHOLESKY DECOMPOSITION BEING GIVEN IN A TWO-DIMENSIONAL ARRAY.
- 34313 57 CHLDETERM1 CALCULATES THE DETERMINANT OF A POSITIVE DEFINITE SYMMETRIC MATRIX, THE CHOLESKY DECOMPOSITION BEING GIVEN COLUMNWISE IN A ONE-DIMENSIONAL ARRAY.
- 34320 75 DECBND PERFORMS A TRIANGULAR DECOMPOSITION OF A BAND MATRIX, USING PARTIAL PIVOTING.
- 34321 77 DETERMBND CALCULATES THE DETERMINANT OF A BAND MATRIX.
- 34322 79 DECSOLBND SOLVES A SYSTEM OF LINEAR EQUATIONS BY GAUSSIAN ELIMINATION WITH PARTIAL PIVOTING IF THE COEFFICIENT MATRIX IS IN BAND FORM AND IS STORED ROWWISE IN A ONE-DIMENSIONAL ARRAY.
- 34330 85 CHLDECBND PERFORMS THE CHOLESKY DECOMPOSITION OF A POSITIVE DEFINITE SYMMETRIC BAND MATRIX.
- 34331 87 CHLDETERMBND CALCULATES THE DETERMINANT OF A POSITIVE DEFINITE SYMMETRIC BAND MATRIX.
- 34332 89 CHLSOLBND SOLVES A POSITIVE DEFINITE SYMMETRIC LINEAR SYSTEM, THE TRIANGULAR DECOMPOSITION BEING GIVEN.
- 34333 89 CHLDECSOLBND SOLVES A POSITIVE DEFINITE SYMMETRIC LINEAR SYSTEM AND PERFORMS THE TRIANGULAR DECOMPOSITION BY CHOLESKY'S METHOD.
- 34340 35 COMABS CALCULATES THE MODULUS OF A COMPLEX NUMBER.
- 34341 37 COMMUL CALCULATES THE PRODUCT OF TWO COMPLEX NUMBERS.
- 34342 37 COMDIV CALCULATES THE QUOTIENT OF TWO COMPLEX NUMBERS.
- 34343 35 COMSQRT CALCULATES THE SQUARE ROOT OF A COMPLEX NUMBER.
- 34344 35 CARPOL TRANSFORMS THE CARTESIAN COORDINATES OF A COMPLEX NUMBER INTO POLAR COORDINATES.
- 34345 129 COMKWD CALCULATES THE ROOTS OF A QUADRATIC EQUATION WITH COMPLEX COEFFICIENTS.
- 34352 21 COMCOLCST MULTIPLIES A COMPLEX COLUMN VECTOR BY A COMPLEX NUMBER.
- 34353 21 COMROWCST MULTIPLIES A COMPLEX ROW VECTOR BY A COMPLEX NUMBER.
- 34354 23 COMMATVEC CALCULATES THE SCALAR PRODUCT OF A COMPLEX ROW VECTOR AND A COMPLEX VECTOR.
- 34355 23 HSHCOMCOL TRANSFORMS A COMPLEX VECTOR INTO A VECTOR PROPORTIONAL TO A UNIT VECTOR.
- 34356 23 HSHCOMPRD PREMULTIPLIES A COMPLEX MATRIX WITH A COMPLEX HOUSEHOLDER MATRIX.
- 34357 287 ROTCOMCOL REPLACES TWO COMPLEX COLUMN VECTORS X AND Y BY TWO COMPLEX VECTORS CX + SY AND CY - SX.
- 34358 287 ROTCOMROW REPLACES TWO COMPLEX ROW VECTORS X AND Y BY TWO COMPLEX VECTORS CX + SY AND CY - SX.
- 34359 31 COMEUCNRM CALCULATES THE EUCLIDEAN NORM OF A COMPLEX MATRIX WITH LW LOWER CODIAGONALS.
- 34360 29 SCLCOM NORMALIZES THE COLUMNS OF A COMPLEX MATRIX.
- 34361 99 EQUILBRCOM EQUILIBRATES A COMPLEX MATRIX.
- 34362 99 BAKLBRCOM TRANSFORMS THE EIGENVECTORS OF A COMPLEX EQUILIBRATED ( BY EQUILBRCOM ) MATRIX INTO THE EIGENVECTORS OF THE ORIGINAL MATRIX.
- 34363 105 HSHHRMTRI TRANSFORMS A HERMITIAN MATRIX INTO A SIMILAR REAL SYMMETRIC TRIDIAGONAL MATRIX.
- 34364 105 HSHHRMTRIVAL DELIVERS THE MAIN DIAGONAL ELEMENTS AND THE SQUARES OF THE CODIAGONAL ELEMENTS OF A HERMITIAN TRIDIAGONAL MATRIX WHICH IS UNITARY SIMILAR WITH A GIVEN HERMITIAN MATRIX.

- 34365 105 BAKHRMTRI PERFORMS THE BACK TRANSFORMATION CORRESPONDING TO HSHHRMTRI.
- 34366 107 HSHCOMHES TRANSFORMS A COMPLEX MATRIX BY MEANS OF HOUSEHOLDER'S TRANSFORMATION FOLLOWED BY A COMPLEX DIAGONAL TRANSFORMATION INTO A SIMILAR UNITARY UPPER- HESSENBERG MATRIX WITH A REAL NONNEGATIVE SUBDIAGONAL.
- 34367 107 BAKCOMHES PERFORMS THE BACK TRANSFORMATION CORRESPONDING TO HSHCOMHES.
- 34368 119 EIGVALHRM CALCULATES THE EIGENVALUES OF A COMPLEX HERMITIAN MATRIX.
- 34369 119 EIGHRM CALCULATES THE EIGENVALUES AND EIGENVECTORS OF A COMPLEX HERMITIAN MATRIX.
- 34370 119 QRIVALHRM CALCULATES THE EIGENVALUES OF A COMPLEX HERMITIAN MATRIX.
- 34371 119 QRIHRM CALCULATES THE EIGENVALUES AND EIGENVECTORS OF A COMPLEX HERMITIAN MATRIX.
- 34372 121 VALQRICOM CALCULATES THE EIGENVALUES OF A COMPLEX UPPER- HESSENBERG MATRIX WITH A REAL SUBDIAGONAL.
- 34373 121 QRICOM CALCULATES THE EIGENVECTORS AND THE EIGENVALUES OF A COMPLEX UPPER- HESSENBERG MATRIX.
- 34374 123 EIGVALCOM CALCULATES THE EIGENVALUES OF A COMPLEX MATRIX.
- 34375 123 EIGCOM CALCULATES THE EIGENVECTORS AND EIGENVALUES OF A COMPLEX MATRIX.
- 34376 25 ELMCOMVECCOL ADDS A COMPLEX NUMBER TIMES A COMPLEX COLUMN VECTOR TO A COMPLEX VECTOR.
- 34377 25 ELMCOMCOL ADDS A COMPLEX NUMBER TIMES A COMPLEX COLUMN VECTOR TO A COMPLEX COLUMN VECTOR.
- 34378 25 ELMCOMROWVEC ADDS A COMPLEX NUMBER TIMES A COMPLEX VECTOR TO A COMPLEX ROW VECTOR.
- 34390 59 CHLSOL2 SOLVES A SYSTEM OF LINEAR EQUATIONS IF THE COEFFICIENT MATRIX HAS BEEN DECOMPOSED BY CHLDEC2 OR CHLDECSOL2.
- 34391 59 CHLSOL1 SOLVES A SYSTEM OF LINEAR EQUATIONS IF THE COEFFICIENT MATRIX HAS BEEN DECOMPOSED BY CHLDEC1 OR CHLDECSOL1.
- 34392 59 CHLDECSOL2 SOLVES A POSITIVE DEFINITE SYMMETRIC SYSTEM OF LINEAR EQUATIONS BY CHOLESKY'S SQUARE ROOT METHOD; THE COEFFICIENT MATRIX SHOULD BE GIVEN IN THE UPPERTRIANGLE OF A TWO-DIMENSIONAL ARRAY.
- 34393 59 CHLDECSOL1 SOLVES A POSITIVE DEFINITE SYMMETRIC SYSTEM OF LINEAR EQUATIONS BY CHOLESKY'S SQUARE ROOT METHOD; THE COEFFICIENT MATRIX SHOULD BE GIVEN COLUMNWISE IN A ONE-DIMENSIONAL ARRAY.
- 34400 61 CHLINV2 CALCULATES THE INVERSE OF A POSITIVE DEFINITE SYMMETRIC MATRIX, IF THE MATRIX HAS BEEN DECOMPOSED BY CHLDEC2 OR CHLDECSOL2.
- 34401 61 CHLINV1 CALCULATES THE INVERSE OF A POSITIVE DEFINITE SYMMETRIC MATRIX, IF THE MATRIX HAS BEEN DECOMPOSED BY CHLDEC1 OR CHLDECSOL1.
- 34402 61 CHLDECINV2 CALCULATES THE INVERSE OF A POSITIVE DEFINITE SYMMETRIC MATRIX BY CHOLESKY'S SQUARE ROOT METHOD; THE COEFFICIENT MATRIX GIVEN COLUMNWISE IN A TWO-DIMENSIONAL ARRAY.
- 34403 61 CHLDECINV1 CALCULATES THE INVERSE OF A POSITIVE DEFINITE SYMMETRIC MATRIX BY CHOLESKY'S SQUARE ROOT METHOD; THE COEFFICIENT MATRIX GIVEN COLUMNWISE IN A ONE-DIMENSIONAL ARRAY.
- 34410 285 LNGVECEVC CALCULATES THE SCALAR PRODUCT OF TWO VECTORS BY DOUBLE LENGTH ARITHMETIC.
- 34411 285 LNGMATVEC CALCULATES THE SCALAR PRODUCT OF A VECTOR AND A ROW VECTOR BY DOUBLE PRECISION ARITHMETIC.
- 34412 285 LNGTAMVEC CALCULATES THE SCALAR PRODUCT OF A VECTOR AND A COLUMN VECTOR BY DOUBLE PRECISION ARITHMETIC.
- 34413 285 LNGMATMAT CALCULATES THE SCALAR PRODUCT OF A ROW OF A VECTOR AND A COLUMN VECTOR BY DOUBLE PRECISION ARITHMETIC.
- 34414 285 LNGTAMMAT CALCULATES THE SCALAR PRODUCT OF TWO COLUMN VECTORS BY DOUBLE PRECISION ARITHMETIC.
- 34415 285 LNGMATTAM CALCULATES THE SCALAR PRODUCT OF TWO ROW VECTORS BY DOUBLE PRECISION ARITHMETIC.
- 34416 285 LNGSEQVEC CALCULATES THE SCALAR PRODUCT OF TWO VECTORS GIVEN IN ONE-DIMENSIONAL



- ARRAYS, WHERE THE MUTUAL SPACINGS BETWEEN THE INDICES OF THE 1ST VECTOR CHANGE LINEARLY, BY DOUBLE LENGTH ARITHMETIC.
- 34417 285 LNGSCAPRD1 CALCULATES THE SCALAR PRODUCT OF TWO VECTORS GIVEN IN ONE-DIMENSIONAL ARRAYS, WHERE THE SPACINGS OF BOTH VECTORS ARE CONSTANT, BY DOUBLE PRECISION ARITHMETIC.
- 34418 285 LNGSYMMATVEC CALCULATES THE SCALAR PRODUCT OF A VECTOR GIVEN IN A ONE-DIMENSIONAL ARRAY AND A ROW OF A SYMMETRIC MATRIX, WHOSE UPPER TRIANGLE IS STORED COLUMNWISE IN A ONE-DIMENSIONAL ARRAY, BY DOUBLE PRECISION ARITHMETIC.
- 34420 91 DECSYMTRI PERFORMS THE TRIANGULAR DECOMPOSITION OF A SYMMETRIC TRIDIAGONAL MATRIX.
- 34421 93 SOLSYMTRI SOLVES A SYMMETRIC TRIDIAGONAL SYSTEM OF LINEAR EQUATIONS, THE TRIANGULAR DECOMPOSITION BEING GIVEN.
- 34422 93 DECSOLSYMTRI SOLVES A SYMMETRIC TRIDIAGONAL SYSTEM OF LINEAR EQUATIONS AND PERFORMS THE TRIDIAGONAL DECOMPOSITION.
- 34423 81 DECTRI PERFORMS A TRIANGULAR DECOMPOSITION OF A TRIDIAGONAL MATRIX.
- 34424 83 SOLTRI SOLVES A TRIDIAGONAL SYSTEM OF LINEAR EQUATIONS THE TRIANGULAR DECOMPOSITION BEING GIVEN.
- 34425 83 DECSOLTRI SOLVES A TRIDIAGONAL SYSTEM OF LINEAR EQUATIONS AND PERFORMS THE TRIANGULAR DECOMPOSITION WITHOUT PIVOTING.
- 34426 81 DECTRIPIV PERFORMS A TRIANGULAR DECOMPOSITION OF A TRIDIAGONAL MATRIX, USING PARTIAL PIVOTING.
- 34427 83 SOLTRIPIV SOLVES A TRIDIAGONAL SYSTEM OF LINEAR EQUATIONS THE TRIANGULAR DECOMPOSITION BEING GIVEN.
- 34428 83 DECSOLTRIPIV SOLVES A TRIDIAGONAL SYSTEM OF LINEAR EQUATIONS AND PERFORMS THE TRIANGULAR DECOMPOSITION WITH PARTIAL PIVOTING.
- 34430 217 QUANEWBND SOLVES A SYSTEM OF NON-LINEAR EQUATIONS OF WHICH THE JACOBIAN ( BEING A BAND MATRIX ) IS GIVEN.
- 34431 217 QUANEWBND1 SOLVES A SYSTEM OF NON-LINEAR EQUATIONS OF WHICH THE JACOBIAN IS A BAND MATRIX.
- 34432 239 PRAXIS MINIMIZES A FUNCTION OF SEVERAL VARIABLES.
- 34433 235 MININ MINIMIZES A FUNCTION OF ONE VARIABLE IN A GIVEN INTERVAL.
- 34435 237 MININDER MINIMIZES A FUNCTION OF ONE VARIABLE IN A GIVEN INTERVAL, USING VALUES OF THE FUNCTION AND OF ITS DERIVATIVE.
- 34436 215 ZEROINRAT FINDS ( IN A GIVEN INTERVAL ) A ZERO OF A FUNCTION OF ONE VARIABLE.
- 34437 213 JACOBNNF CALCULATES THE JACOBIAN MATRIX OF AN N-DIMENSIONAL FUNCTION OF N VARIABLES USING FORWARD DIFFERENCES.
- 34438 213 JACOBNMF CALCULATES THE JACOBIAN MATRIX OF AN N-DIMENSIONAL FUNCTION OF M VARIABLES USING FORWARD DIFFERENCES.
- 34439 213 JACOBNBNDF CALCULATES THE JACOBIAN MATRIX OF AN N-DIMENSIONAL FUNCTION OF N VARIABLES, IF THE JACOBIAN IS KNOWN TO BE A BAND MATRIX.
- 34440 219 MARQUARDT CALCULATES THE LEAST SQUARES SOLUTION OF AN OVERDETERMINED SYSTEM OF NON-LINEAR EQUATIONS WITH MARQUARDT'S METHOD.
- 34441 219 GSSNEWTON CALCULATES THE LEAST SQUARES SOLUTION OF AN OVERDETERMINED SYSTEM OF NON-LINEAR EQUATIONS WITH THE GAUSS-NEWTON METHOD.
- 34444 259 PEIDE ESTIMATES UNKNOWN PARAMETERS IN A SYSTEM OF 1ST ORDER DIFFERENTIAL EQUATIONS; THE UNKNOWN VARIABLES MAY APPEAR NON-LINEARLY BOTH IN THE DIFFERENTIAL EQUATIONS AND ITS INITIAL VALUES; A SET OF OBSERVED VALUES OF SOME COMPONENTS OF THE SOLUTION OF THE DIFFERENTIAL EQUATIONS MUST BE GIVEN.
- 34453 233 ZEROINDER FINDS ( IN A GIVEN INTERVAL ) A ZERO OF A FUNCTION OF ONE VARIABLE USING VALUES OF THE FUNCTION AND OF ITS DERIVATIVE.
- 34500 209 POLZEROS CALCULATES ALL ZEROS OF A POLYNOMIAL WITH REAL COEFFICIENTS.
- 34501 311 ZERPOL CALCULATES ALL ROOTS ( ZEROS ) OF A POLYNOMIAL WITH REAL COEFFICIENTS BY LAGUERRE'S METHOD.
- 34502 311 BOUNDS CALCULATES THE ERROR IN APPROXIMATED ZEROS OF A POLYNOMIAL WITH REAL COEFFICIENTS.
- 34600 267 QZIVAL COMPUTES GENERALIZED EIGENVALUES BY MEANS OF QZ-ITERATION.

- 34601 267 QZI COMPUTES GENERALIZED EIGENVALUES AND EIGENVECTORS BY MEANS OF QZ-ITERATION.
- 34602 267 HSHDECMUL IS AN AUXILIARY PROCEDURE FOR THE COMPUTATION OF GENERALIZED EIGENVALUES.
- 34603 267 HESTGL3 IS AN AUXILIARY PROCEDURE FOR THE COMPUTATION OF GENERALIZED EIGENVALUES.
- 34604 267 HESTGL2 IS AN AUXILIARY PROCEDURE FOR THE COMPUTATION OF GENERALIZED EIGENVALUES.
- 34605 267 HSH2COL IS AN AUXILIARY PROCEDURE FOR THE COMPUTATION OF GENERALIZED EIGENVALUES.
- 34606 267 HSH3COL IS AN AUXILIARY PROCEDURE FOR THE COMPUTATION OF GENERALIZED EIGENVALUES.
- 34607 267 HSH2ROW3 IS AN AUXILIARY PROCEDURE FOR THE COMPUTATION OF GENERALIZED EIGENVALUES.
- 34608 267 HSH2ROW2 IS AN AUXILIARY PROCEDURE FOR THE COMPUTATION OF GENERALIZED EIGENVALUES.
- 34609 267 HSH3ROW3 IS AN AUXILIARY PROCEDURE FOR THE COMPUTATION OF GENERALIZED EIGENVALUES.
- 34610 267 HSH3ROW2 IS AN AUXILIARY PROCEDURE FOR THE COMPUTATION OF GENERALIZED EIGENVALUES.
- 34611 287 CHSH2 FINDS A COMPLEX ROTATION MATRIX.
- 35021 227 ERRORFUNCTION COMPUTES THE ERROR FUNCTION ( ERF ) AND COMPLEMENTARY ERROR FUNCTION ( ERFC ) FOR A REAL ARGUMENT.
- 35022 227 NONEXPERFC COMPUTES  $\text{ERFC}(X) * \text{EXP}(X**X)$ .
- 35023 227 INVERSE ERROR FUNCTION CALCULATES THE INVERSE ERROR FUNCTION  $Y = \text{INVERF}(X)$ .
- 35027 227 FRESNEL CALCULATES THE FRESNEL INTEGRALS  $C(X)$  AND  $S(X)$ .
- 35028 227 FG IS AN AUXILIARY PROCEDURE FOR THE COMPUTATION OF FRESNEL INTEGRALS.
- 35030 187 INCOMGAM COMPUTES THE INCOMPLETE GAMMA FUNCTIONS.
- 35050 187 INCBETA COMPUTES THE INCOMPLETE BETA-FUNCTION  $I(X,P,Q)$ ;  $0 \leq X \leq 1$ ,  $P > 0$ ,  $Q > 0$ .
- 35051 187 IBPPLUSN COMPUTES INCOMPLETE BETA-FUNCTION RATIOS  $I(X,P+N,Q)$  FOR  $N = 0$  (1)  $NMAX$ ,  $0 \leq X \leq 1$ ,  $P > 0$ ,  $Q > 0$ .
- 35052 187 IBQPLUSN COMPUTES INCOMPLETE BETA-FUNCTION RATIOS  $I(X,P,Q+N)$  FOR  $N = 0$  (1)  $NMAX$ ,  $0 \leq X \leq 1$ ,  $P > 0$ ,  $Q > 0$ .
- 35053 187 IXQFIX IS AN AUXILIARY PROCEDURE FOR THE COMPUTATION OF INCOMPLETE BESSELFUNCTIONS.
- 35054 187 IXPFIX IS AN AUXILIARY PROCEDURE FOR THE COMPUTATION OF INCOMPLETE BESSELFUNCTIONS.
- 35055 187 FORWARD IS AN AUXILIARY PROCEDURE FOR THE COMPUTATION OF INCOMPLETE BESSELFUNCTIONS.
- 35056 187 BACKWARD IS AN AUXILIARY PROCEDURE FOR THE COMPUTATION OF INCOMPLETE BESSELFUNCTIONS.
- 35060 187 RECIP GAMMA CALCULATES THE RECIPROCAL OF THE GAMMA FUNCTION FOR ARGUMENTS IN THE RANGE  $[.5, 1.5]$ ; MOREOVER ODD AND EVEN PARTS ARE DELIVERED.
- 35061 187 GAMMA CALCULATES THE GAMMA FUNCTION.
- 35062 187 LOG GAMMA CALCULATES THE NATURAL LOGARITHM OF THE GAMMA FUNCTION FOR POSITIVE ARGUMENTS.
- 35080 183 EI CALCULATES THE EXPONENTIAL INTEGRAL .
- 35081 183 EI ALPHA CALCULATES A SEQUENCE OF INTEGRALS OF THE FORM  $\int_1^T (\text{EXP}(-X*T)) * T**N \text{ DT}$ , FROM  $T=1$  TO  $T=\text{INFINITY}$ .
- 35083 41 JFRAC CALCULATES A TERMINATING CONTINUED FRACTION.
- 35084 185 SINCSINT CALCULATES THE SINE INTEGRAL  $SI(X)$  AND THE COSINE INTEGRAL  $CI(X)$ .
- 35085 185 SINCSFG IS AN AUXILIARY PROCEDURE FOR THE SINE AND COSINE INTEGRALS.
- 35086 183 ENX COMPUTES A SEQUENCE OF EXPONENTIAL INTEGRALS  $E(N,X) = \text{THE INTEGRAL FROM 1 TO INFINITY OF } \text{EXP}(-X * T) / T**N \text{ DT}$ .
- 35087 183 NONEXP ENX COMPUTES A SEQUENCE OF INTEGRALS  $\text{EXP}(X) * E(N,X)$ .

35111 181 SINH COMPUTES THE HYPERBOLIC SINE FOR A REAL ARGUMENT X.  
 35112 181 COSH COMPUTES THE HYPERBOLIC COSINE FOR A REAL ARGUMENT X.  
 35113 181 TANH COMPUTES THE HYPERBOLIC TANGENT FOR A REAL ARGUMENT X.  
 35114 181 ARCSINH COMPUTES THE INVERSE HYPERBOLIC SINE FOR A REAL ARGUMENT X.  
 35115 181 ARCCOSH COMPUTES THE INVERSE HYPERBOLIC COSINE FOR A REAL ARGUMENT X.  
 35116 181 ARCTANH COMPUTES THE INVERSE HYPERBOLIC TANGENT FOR A REAL ARGUMENT X.  
 35120 179 TAN COMPUTES THE TANGENT FOR A REAL ARGUMENT X.  
 35121 179 ARCSIN COMPUTES THE ARCSINE FOR A REAL ARGUMENT X.  
 35122 179 ARCCOS COMPUTES THE ARCCOSINE FOR A REAL ARGUMENT X.  
 35130 315 LOGONEPLUSX EVALUATES THE LOGARITHMIC FUNCTION  $\text{LN}(1+X)$ .  
 35140 243 AIRY EVALUATES THE AIRY FUNCTIONS  $\text{AI}(Z)$  AND  $\text{BI}(Z)$  AND THEIR DERIVATIVES.  
 35145 243 AIRYZEROS COMPUTES THE ZEROS AND ASSOCIATED VALUES OF THE AIRY FUNCTIONS  $\text{AI}(Z)$  AND  $\text{BI}(Z)$  AND THEIR DERIVATIVES.  
 35150 247 SPHER BESS J CALCULATES THE SPHERICAL BESSEL FUNCTIONS OF THE 1ST KIND:  
 $\text{JCK}+.5\text{J}(X)*\text{SQRT}(\text{PI}/(2*X))$ ,  $K=0,...,N$ , WHERE  $\text{JCK}+.5\text{J}(X)$  DENOTES THE BESSEL  
 FUNCTION OF THE 1ST KIND OF ORDER  $K+.5$ .  
 35151 247 SPHER BESS Y CALCULATES THE SPHERICAL BESSEL FUNCTIONS OF THE 3RD KIND:  
 $\text{YCK}+.5\text{J}(X)*\text{SQRT}(\text{PI}/(2*X))$ ,  $K=0,...,N$ , WHERE  $\text{YCK}+.5\text{J}(X)$  DENOTES THE BESSEL  
 FUNCTION OF THE 3RD KIND OF ORDER  $K+.5$ .  
 35152 247 SPHER BESS I CALCULATES THE MODIFIED SPHERICAL BESSEL FUNCTIONS OF THE 1ST  
 KIND:  $\text{ICK}+.5\text{J}(X)*\text{SQRT}(\text{PI}/(2*X))$ ,  $K=0,...,N$ , WHERE  $\text{ICK}+.5\text{J}(X)$  DENOTES THE  
 MODIFIED BESSEL FUNCTION OF THE 1ST KIND OF ORDER  $K+.5$ .  
 35153 247 SPHER BESS K CALCULATES THE MODIFIED SPHERICAL BESSEL FUNCTIONS OF THE 3RD  
 KIND:  $\text{KCI}+.5\text{J}(X)*\text{SQRT}(\text{PI}/(2*X))$ ,  $I=0,...,N$ , WHERE  $\text{KCI}+.5\text{J}(X)$  DENOTES THE  
 MODIFIED BESSEL FUNCTION OF THE 3RD KIND OF ORDER  $I+.5$ .  
 35154 247 NONEXP SPHER BESS I CALCULATES THE MODIFIED SPHERICAL BESSEL FUNCTIONS OF THE  
 1ST KIND MULTIPLIED BY  $\text{EXP}(-X)$ :  $\text{ICK}+.5\text{J}(X)*\text{SQRT}(\text{PI}/(2*X))*\text{EXP}(-X)$ ,  $K=0,...,N$ ,  
 WHERE  $\text{ICK}+.5\text{J}(X)$  DENOTES THE MODIFIED BESSEL FUNCTION OF THE 1ST KIND OF ORDER  
 $K+.5$ .  
 35155 247 NONEXP SPHER BESS K CALCULATES THE MODIFIED SPHERICAL BESSEL FUNCTIONS OF THE  
 3RD KIND MULTIPLIED BY  $\text{EXP}(-X)$ :  $\text{KCI}+.5\text{J}(X)*\text{SQRT}(\text{PI}/(2*X))*\text{EXP}(-X)$ ,  $I=0,...,N$ ,  
 WHERE  $\text{KCI}+.5\text{J}(X)$  DENOTES THE MODIFIED BESSEL OF THE 3RD KIND OF ORDER  $I+.5$ .  
 35160 253 BESS J0 CALCULATES THE ORDINARY BESSEL FUNCTION OF THE 1ST KIND OF ORDER  
 ZERO.  
 35161 253 BESS J1 CALCULATES THE ORDINARY BESSEL FUNCTION OF THE 1ST KIND OF ORDER ONE.  
 35162 253 BESS J CALCULATES THE ORDINARY BESSEL FUNCTIONS OF THE 1ST KIND OF ORDER  $L$  ( $L$   
 $= 0,...,N$ ).  
 35163 253 BESS Y01 CALCULATES THE ORDINARY BESSEL FUNCTIONS OF THE 2ND KIND ORDER ZERO  
 AND ONE WITH ARGUMENT  $X$ ;  $X > 0$ .  
 35164 253 BESS Y CALCULATES THE ORDINARY BESSEL FUNCTIONS OF THE 2ND KIND OF ORDER  $L$  ( $L$   
 $= 0,...,N$ ) WITH ARGUMENT  $X$ ;  $X > 0$ .  
 35165 253 BESS PQ0 IS AN AUXILIARY PROCEDURE FOR THE COMPUTATION OF THE ORDINARY BESSEL  
 FUNCTIONS OF ORDER ZERO FOR LARGE VALUES OF THEIR ARGUMENT.  
 35166 253 BESS PQ1 IS AN AUXILIARY PROCEDURE FOR THE COMPUTATION OF THE ORDINARY BESSEL  
 FUNCTIONS OF ORDER ONE FOR LARGE VALUES OF THEIR ARGUMENT.  
 35170 255 BESS I0 CALCULATES THE MODIFIED BESSEL FUNCTION OF THE 1ST KIND OF ORDER  
 ZERO.  
 35171 255 BESS I1 CALCULATES THE MODIFIED BESSEL FUNCTION OF THE 1ST KIND OF ORDER ONE.  
 35172 255 BESS I CALCULATES THE MODIFIED BESSEL FUNCTIONS OF THE 1ST KIND OF ORDER  $L$  ( $L$   
 $= 0,...,N$ ).  
 35173 255 BESS K01 CALCULATES THE MODIFIED BESSEL FUNCTIONS OF THE 3RD KIND OF ORDERS  
 ZERO AND ONE WITH ARGUMENT  $X$ ;  $X > 0$ .  
 35174 255 BESS K CALCULATES THE MODIFIED BESSEL FUNCTIONS OF THE 3RD KIND OF ORDER  $L$  ( $L$   
 $= 0,...,N$ ) WITH ARGUMENT  $X$ ;  $X > 0$ .  
 35175 255 NONEXP BESS I0 CALCULATES THE MODIFIED BESSEL FUNCTION OF THE 1ST KIND OF ORDER  
 ZERO; THE RESULT IS MULTIPLIED BY  $\text{EXP}(-\text{ABS}(X))$ .

- 35176 255 NONEXP BESS I1 CALCULATES THE MODIFIED BESSEL FUNCTION OF THE 1ST KIND OF ORDER ONE; THE RESULT IS MULTIPLIED BY  $\exp(-\text{ABS}(X))$
- 35177 255 NONEXP BESS I CALCULATES THE MODIFIED BESSEL FUNCTIONS OF THE 1ST KIND OF ORDER  $L$  ( $L = 0, \dots, N$ ); THE RESULT IS MULTIPLIED BY  $\exp(-\text{ABS}(X))$ .
- 35178 255 NONEXP BESS K01 CALCULATES THE MODIFIED BESSEL FUNCTIONS OF THE 3RD KIND OF ORDER ZERO AND ONE WITH ARGUMENT  $X$ ,  $X > 0$ ; THE RESULT IS MULTIPLIED BY  $\exp(X)$ .
- 35179 255 NONEXP BESS K CALCULATES THE MODIFIED BESSEL FUNCTIONS OF THE 3RD KIND OF ORDER  $L$  ( $L = 0, \dots, N$ ) WITH ARGUMENT  $X$ ,  $X > 0$ ; THE RESULT IS MULTIPLIED BY  $\exp(X)$ .
- 35180 249 BESS JAPLUSN CALCULATES THE BESSEL FUNCTIONS OF THE 1ST KIND OF ORDER  $A+K$  ( $0 \leq K \leq N$ ,  $0 \leq A < 1$ ).
- 35181 249 BESS YA01 CALCULATES THE BESSEL FUNCTIONS OF THE 2ND KIND (ALSO CALLED NEUMANN'S FUNCTIONS) OF ORDER  $A$  AND  $A+1$  ( $A \geq 0$ ) AND ARGUMENT  $X > 0$ .
- 35182 249 BESS YAPLUSN CALCULATES THE BESSEL FUNCTIONS OF THE 2ND KIND OF ORDER  $A+N$ ,  $N=0, \dots, NMAX$ ,  $A \geq 0$ , AND ARGUMENT  $X > 0$ .
- 35183 249 BESS PQA01 IS AN AUXILIARY PROCEDURE FOR THE COMPUTATION OF THE BESSEL FUNCTIONS FOR LARGE VALUES OF THEIR ARGUMENT.
- 35184 249 BESSZEROS CALCULATES ZEROS OF A BESSELFUNCTION (OF 1ST OR 2ND KIND) AND OF ITS DERIVATIVE.
- 35185 249 START IS AN AUXILIARY PROCEDURE IN BESSELFUNCTION PROCEDURES.
- 35190 251 BESS IAPLUSN CALCULATES THE MODIFIED BESSEL FUNCTIONS OF THE 1ST KIND OF ORDER  $A+N$ ,  $N=0, \dots, NMAX$ ,  $A \geq 0$  AND ARGUMENT  $X \geq 0$ .
- 35191 251 BESS KA01 CALCULATES THE MODIFIED BESSEL FUNCTIONS OF THE 3RD KIND OF ORDER  $A$  AND  $A+1$ ,  $A \geq 0$ , AND ARGUMENT  $X$ ,  $X > 0$ .
- 35192 251 BESS KAPLUSN CALCULATES THE MODIFIED BESSEL FUNCTIONS OF THE 3RD KIND OF ORDER  $A+N$ ,  $N=0, \dots, NMAX$ ,  $A \geq 0$ , AND ARGUMENT  $X > 0$ .
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